ERCOT Independent Review of the AEPSC and Oncor Far West Texas Project

Version 1.0

Document Revisions

Date	Version	Description	Author(s)
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1. Executive Summary

Over the past several years the load on the Wink – Culberson – Yucca Drive 138 kV transmission loop ("Culberson loop") and the load in the Barilla Junction area have experienced high load growth. Oncor has projected annual load growth rates as high as 11% over the next five years on the Culberson loop. Additionally, both areas, located in Far West Texas, have had an increase in requests for generator interconnections. Over 1,600 MW of solar resources are expected to come online in Pecos and Southwest Upton Counties between 2016 and 2020.

On April 20, 2016, Oncor and AEPSC submitted the Far West Texas Project (FWTP) to the Regional Planning Group (RPG) to address the transmission needs both in the Culberson loop area and the Barilla Junction area. The proposed project was estimated to cost $423 million and classified as a Tier 1 project. The proposed in-service date range for the FWTP was 2021-2022.

Based on the FWTP proposal, ERCOT completed this independent review to determine the system needs and address those needs in a cost-effective manner while providing the flexibility to meet potential load and generating capacity growth in this region. ERCOT also performed sensitivity studies in compliance with the ERCOT Planning Guide.

Based on the forecasted loads and scenarios analyzed, ERCOT determined that there is a reliability need to improve the transmission system in Far West Texas. After consideration of the project alternatives, ERCOT concluded that the upgrades identified in Option 2 meet the reliability criteria in the most cost effective manner and have multiple expansion paths to accommodate future load growth in the area of study. Option 2 is estimated to cost $336 million and is described as follows:

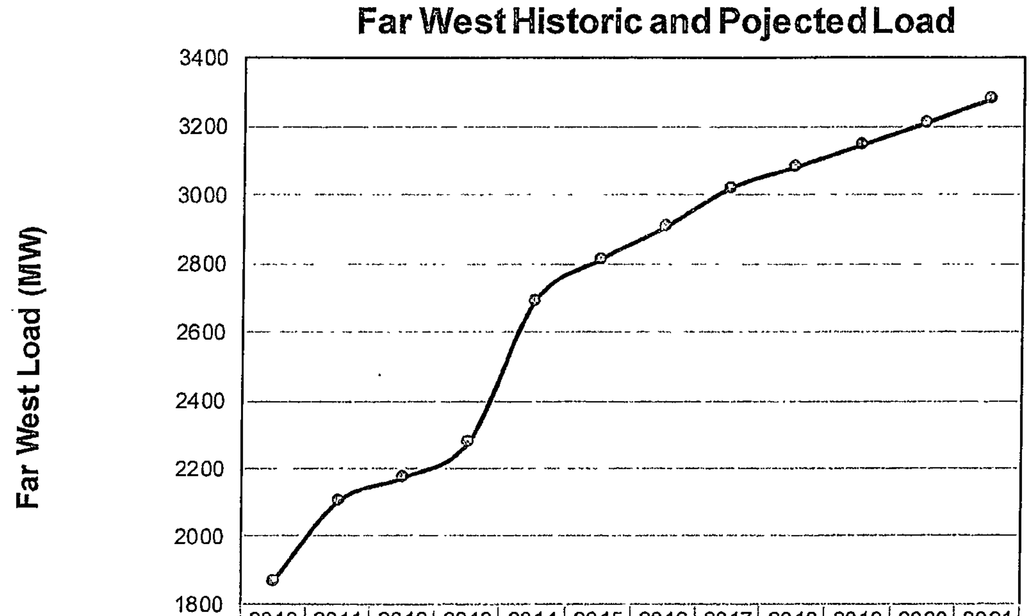
- Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers
- Construct a new, approximately 85-mile, 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station, Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV Switch Station. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV Switch Station to create the new Odessa EHV – Riverton 345 kV Line
- Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers
- Construct a new, approximately 68-mile, 345 kV line from Solstice Switch Station to Bakersfield Station on double-circuit structures with one circuit in place

Although this option is not the exact configuration included in the FWTP proposal, it is a subset of that configuration with two autotransformer additions. ERCOT has determined that the alternative transmission expansion option, Option 2, will provide the most cost-effective configuration to meet the load forecast developed from contractual agreements. It will also allow a number of different possible expansion options that could augment the Far West Texas transmission grid load serving capability beyond the forecasts developed exclusively from committed load additions.

2. Introduction

Over the past several years the Far West Texas Weather Zone has experienced high load growth. Between 2010 and 2016 the average annual growth rate was roughly 8%. This strong growth rate was primarily driven by increases in oil and natural gas related demand. The most recent ERCOT 90th percentile summer non-coincident peak load forecast projects an average annual Far West Weather Zone growth rate of about 2.4% between 2016 and 2020.

Figure 2.1 shows historic and projected summer non-coincident peak load levels for the Far West Weather Zone.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Far-West Load (MW)	1867	2103	2172	2279	2688	2812	2909	3023	3084	3148	3212	3281
Growth (%)	7.4%	12.6%	3.3%	4.9%	18.0%	4.6%	3.5%	3.9%	2.0%	2.1%	2.0%	2.2%

Figure 2.1: Far West Weather Zone historic peak load and ERCOT 90th percentile summer non-coincident peak load forecast

The Transmission Service Providers (TSPs) in the area including Oncor, TNMP and AEPSC have also identified high load growth rates concentrated in the Delaware Basin area. Oncor has projected annual load growth rates ranging as high as 11% over the next five years within a portion of the Far West Weather Zone, including Culberson, Reeves, Loving, Ward and Winkler Counties, based on committed customer load requests.

The area southwest of Odessa, served by the 69 kV and 138 kV lines between Permian Basin, Barilla Junction, Fort Stockton Plant, and Rio Pecos stations ("Barilla Junction area") has seen increased load growth along with solar generation development. AEPSC has projected that the Barilla Junction area load will grow to over 500 MW by 2021 with over 160 MW being served by the Yucca Drive – Barilla Junction 138 kV line alone. There are over 1,600 MW of solar resources that meet the conditions of Planning Guide Section 6.9 for inclusion in the base cases and that are expected to come online in Pecos and Southwest Upton Counties between 2016 and 2020. These generators are listed in Table 2.1.

Table 2.1 Solar Generation coming online in Pecos and Upton between 2016 and 2020

INR	Project Name	Fuel	Projected COD	Total Capacity	County
12INR0059b	Barilla Solar 1B	Solar	7/1/2016	7	Pecos
16INR0048	RE Rose Rock Solar	Solar	10/31/2016	160	Pecos
16INR0073	East Pecos Solar	Solar	12/1/2016	120	Pecos
16INR0065	Castle Gap Solar	Solar	1/11/2017	117	Upton
15INR0070_1	West Texas Solar	Solar	2/1/2017	110	Pecos
15INR0045	Riggins Solar	Solar	2/16/2017	150	Pecos
15INR0070_1b	Pearl Solar	Solar	4/28/2017	50	Pecos
16INR0065b	SP-TX-12-Phase B	Solar	8/15/2017	120	Upton
16INR0065a	Castle Gap Solar 2	Solar	9/6/2017	63	Upton
17INR0020a	RE Maplewood 2a Solar	Solar	10/1/2018	100	Pecos
16INR0114	Upton Solar	Solar	12/1/2018	102	Upton
15INR0059	Pecos Solar I	Solar	1/1/2019	108	Pecos
17INR0020b	RE Maplewood 2b Solar	Solar	5/16/2019	200	Pecos
17INR0020c	RE Maplewood 2c Solar	Solar	1/1/2020	100	Pecos
17INR0020d	RE Maplewood 2d Solar	Solar	7/15/2020	100	Pecos

On April 20, 2016, Oncor and AEPSC submitted the Far West Texas Project (FWTP) to the Regional Planning Group (RPG) to address the transmission needs both in the Barilla Junction area and the Wink – Culberson – Yucca Drive 138 kV transmission loop ("Culberson loop"). This project was estimated to cost $423 million and was classified as a Tier 1 project. Figure 2.2 shows the proposed FWTP. The major components of this project proposal were:

- A new 101-mile Odessa EHV – Riverton 345 kV line on a double circuit structure with a single circuit installed
- Expansion of the Riverton Switch Station to install a 3-breaker 345 kV ring-bus arrangement with one 600 MVA, 345/138 kV autotransformer
- Expansion of the Solstice Switch Station to install a 3-breaker 345 kV ring-bus arrangement with one 675 MVA, 345/138 kV autotransformer
- A new 66-mile Riverton – Solstice 345 kV line on a double circuit structure with a single circuit installed
- A new 345 kV Lynx Switch Station with a 5-breaker 345 kV ring-bus arrangement and one 675 MVA, 345/138 kV autotransformer
- A new 59-mile Solstice – Lynx 345 kV Line on a double circuit structure with a single circuit installed
- A new 9-mile Lynx – Bakersfield 345 kV Line on a double circuit structure with a single circuit installed

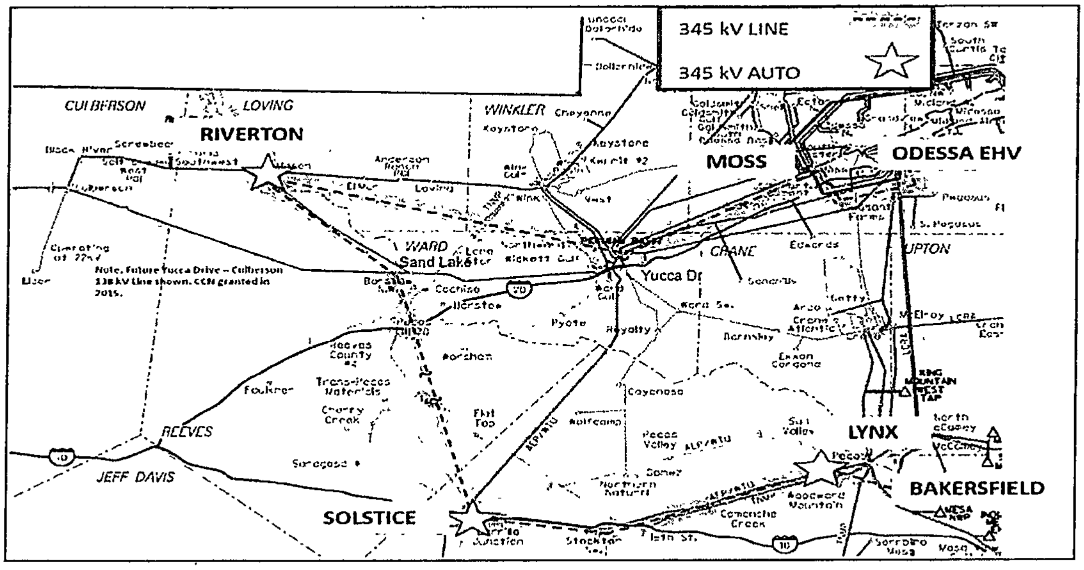


Figure 2.2: Proposed Far West Texas Project

Based on the FWTP proposal, ERCOT completed this independent review to determine the system needs in the Barilla Junction and Culberson loop areas and address those needs in a cost-effective manner while providing the flexibility to meet potential load and generating capacity growth in this region.

3. Study Assumption and Methodology

ERCOT performed studies under various system conditions to evaluate the system need and identify a cost-effective solution to meet those needs in the area. The assumptions and criteria used for this review are described in this section.

3.1. Study Assumption

The primary focus of this review are the Barilla Junction Area and Wink – Culberson – Yucca Drive loop transmission system.

Figure 3.1 shows the system map of the study area. The Barilla Junction and Culberson loop areas are highlighted in rectangles.

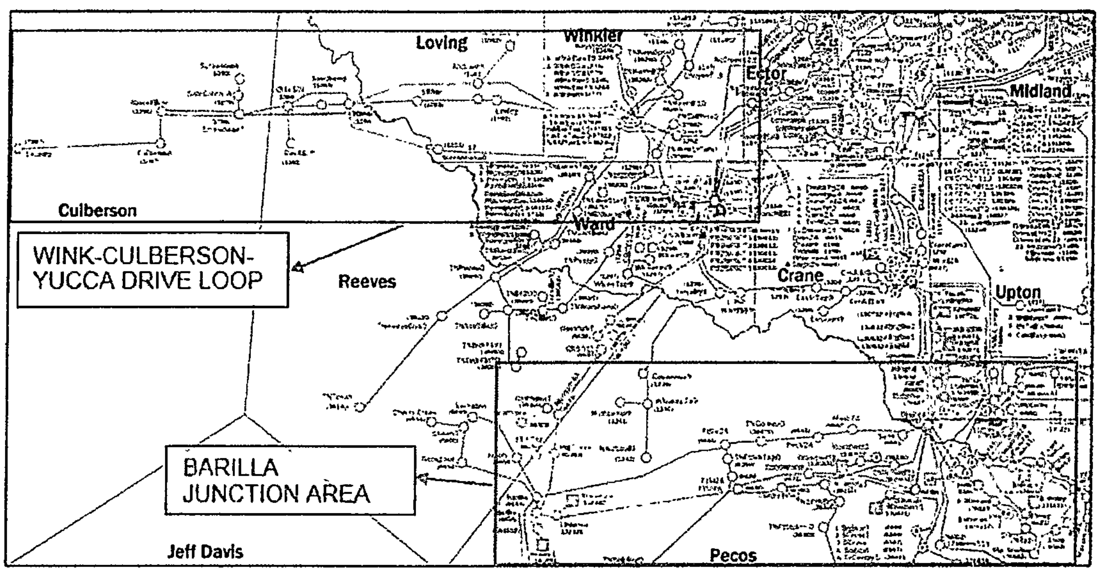


Figure 3.1: Transmission System Map of Study Area

3.1.1. Reliability Cases

The following starting cases were used in the study:

- The 2021 West/Far West (WFW) summer peak case from the 2016 RTP (based on the 2015 Steady State Working Group (SSWG) cases)
- The 2022 Dynamic Working Group summer peak flat start case

3.1.2. Transmission Topology

The starting case was modified based on input from AEPSC and Oncor to include topological changes, switched shunt additions and load additions in the study area. AEPSC provided system changes to the 138 kV line from Pig Creek to Yucca Drive via Gas Pad Tap. This section was upgraded to 966 MVA. The changes also included a switched shunt device at Hackberry Draw Tap 138 kV substation.

Oncor also provided topological updates to the Wink – Culberson – Yucca Drive loop. The changes included the new Riverton and Mentone substations, and a new Riverton-Mentone-Sand Lake 138 kV line along with other new buses and branches to accommodate new load additions in the Culberson loop. The changes also included a switched shunt added to the Whiting Oil 138 kV bus.

3.1.3. Study Case Loads and Potential Loads

The TSPs also provided data which increased the load in the Barilla Junction and Culberson loop areas. The original Oncor and AEPSC RPG submittal data included about 425 MW of load in the Culberson loop area and 511 MW in the Barilla Junction area by year 2021. These projections were later modified by Oncor to include additional confirmed load contracts for the Culberson loop during the ERCOT independent review. AEPSC also provided updated load information for the Barilla Junction area and some of the loads originally designated as conforming were modified to be non-conforming. After all the changes were incorporated the "Study Case" for 2021 had a total projected load of 533 MW along the Culberson loop and 511 MW of total load in the Barilla Junction area. Both AEPSC and Oncor met with ERCOT and shared information on the signed customer agreements and confirmed these proposed load additions.

Sensitivity cases were also created to reflect higher load projections from Oncor and AEPSC. These cases contained additional customer load requests that did not yet have firm commitment at the time of this independent review. To reflect this "Potential" load growth, the load was increased by 277 MW in the Culberson loop and 57 MW in the Barilla Junction area above the Study Case load. The total load in the Potential Load Case was approximately 810 MW and 568 MW in the Culberson loop and Barilla Junction area, respectively, for the Potential Load sensitivity.

3.1.4. Generation

Planned generators in the Far West and West Weather Zones that met Planning Guide Section 6.9 conditions for inclusion in the base cases (according to the 2016 October Generation Interconnection Status report), which were not included in the RTP cases, were added. The added generators are listed in Table 3.1.

Key assumptions applied in this study include the following:

- Wind generation in West and Far West weather zones were set to have a maximum dispatch capability of 2.6% of their rated capacity. This assumption was in accordance with the 2016 Regional Transmission Plan Study Scope and Process document[1].
- Solar generation was set at 70% of their rated capacity in accordance with the 2016 Regional Transmission Plan Study Scope and Process document.

Table 3.1 Added Generators That Met Planning Guide Section 6.9 Conditions (2016 October GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
16INR0023	BNB Lamesa Solar (Phase I)	102	Solar	Dawson	Far West
16INR0065a	Castle Gap Solar 2	63	Solar	Upton	Far West
17INR0020a	RE Maplewood 2a Solar	100	Solar	Pecos	Far West
17INR0020b	RE Maplewood 2b Solar	200	Solar	Pecos	Far West
17INR0020c	RE Maplewood 2c Solar	100	Solar	Pecos	Far West
17INR0020d	RE Maplewood 2d Solar	100	Solar	Pecos	Far West
15INR0061	Solaire Holman 1	50	Solar	Brewster	Far West

3.1.5. No Solar Scenarios

The Far West and West Weather Zones have a significant amount of solar generation, and the maximum output of solar generation modeled in the Study Case and the Potential Load Case was

[1] http://www.ercot.com/content/wcm/key_documents_lists/77730/2016_RTP_Scope_Process_v1.3_clean.pdf

1,340 MW based on limiting the dispatch to about 70% of maximum capacity (maximum capacity was about 1,912 MW). To study system conditions when solar generation is not available, a 9:00 pm summer peak load condition case was created for both the Study Cases and Potential Load Cases. To create this "No Solar" peak condition, the load in the Far West Weather Zone was reduced by 6% based on a review of the historic Far West Weather Zone summer peak conditions from 2014-2016 at the time of peak and at 9:00 pm when the sun has set and solar generation output is expected to be near zero. Therefore, the load was scaled down in the Far West Weather Zone to reflect expected demand conditions at 9:00 pm for the "No Solar" scenarios.

3.1.6. Capital Cost Estimates

Capital costs estimates for transmission facilities were provided by Oncor, AEPSC and LCRA TSC. These cost were provided for individual transmission facilities and ERCOT used those values to calculate total project costs for various project options.

3.2. Criteria for Violations

All the violations identified in this report used the criteria described in this section.

All 100 kV and above busses, transmission lines, and transformers in the study region were monitored (excluding generator step-up transformers).

- Thermal violation
    - Use Rate A for Normal Conditions
    - Use Rate B for Emergency Conditions
- Voltage violation criteria
    - 0.95 < V pu < 1.05 Normal
    - 0.90 < V pu < 1.05 Emergency
    - Post Contingency voltage deviations
        - > 8% on non-radial load buses
- Voltage Stability Analysis
    - PV calculations for load transfer (Culberson loop)

3.3. Study Tools

ERCOT utilized the following software tools for the independent review of the Far West Texas Project:

- PSS/e version 33 was used to perform the dynamic stability analysis and to incorporate the TSP changes (idevs) in the initial steady-state case
- PowerWorld Simulator version 19 for SCOPF and steady state contingency analysis
- VSAT version 15 was used for voltage stability analysis
- UPLAN

4. Project Need

The need for a transmission improvement project was evaluated for the Study Case with both the base case and "No Solar" scenarios. The steady state analysis results showed transmission line overloading in the Barilla Junction area and voltage instability (unsolved contingencies) in the Culberson loop area under N–1 contingency analysis. The results of the steady state violations are summarized in Tables 4.1 – 4.4.

Table 4.1 2021 Thermal Overloading in the Study Region under N-1 Conditions

Element	Length (miles)	Study Case	No Solar Case
16th Street TNP to Woodward2 138 kV ckt 1	31.8	101%	115%
Rio Pecos to Woodward2 138 kV ckt 1	1.9	No Violation	106%
Rio Pecos to Woodward1 Tap 138 kV ckt 1	2.2	No Violation	106%
Tombstone to Woodward1 Tap 138 kV ckt 1	15.7	No Violation	106%

Table 4.2 2021 Unsolvable contingencies

#	Contingency (Category)	Study Case	No Solar Case
1	CEII	Unsolved	Unsolved

Table 4.3 2021 Voltage Violations in the Study Region under N-1 Conditions

Bus	Nominal Voltage (KV)	Study Case	No Solar Case
Salt Creek South Poi	138	0.873	0.893
Black River	138	0.878	0.896
Mentone SW	138	0.880	0.897
Mentcryo	138	0.885	0.898
Coalsndr	138	0.880	0.898
Sandlake	138	0.881	0.898
Sand Bend Poi	138	0.877	0.898
Culberson2	138	0.880	0.898
Orla Plant	138	0.865	0.899
Culberson	138	0.881	0.899
Culberson Wind Farm	138	0.881	0.899
Elmar	138	0.890	No Violation
Kunitz	138	0.883	No Violation
Mason (Oncor)	138	0.885	No Violation
Orla Southwest Poi	138	0.869	No Violation
Riverton	138	0.878	No Violation
Salt Creek West Poi	138	0.880	No Violation
Screwbean Tap	138	0.881	No Violation

Table 4.4 2021 Voltage Deviations in the Study Region under N-1 Conditions

Bus	Nominal Voltage (KV)	Study Case	No Solar Case
Kunitz	138	< 8%	9.2%
Mason (Oncor)	138	< 8%	8.7%
Orla Southwest Poi	138	< 8%	9.0%
Pig Creek Tap	138	< 8%	8.6%
Riverton	138	< 8%	8.8%
Salt Creek West Poi	138	< 8%	9.1 %
Screw bean Tap	138	< 8%	9.1%
Wolfbone Tap TNP	138	< 8%	10.0%
Woodward 1 Tap	138	< 8%	8.5%
Woodward 1	138	< 8%	8.5%

The unsolvable contingency identified in Table 4.2 and voltage violations listed in Table 4.4 indicated a local voltage stability challenge in the Culberson loop area. The detailed steady state results for the Study Case with and without solar can be found in the Appendix.

Figure 4.1 shows the thermal violations seen in the Study case.

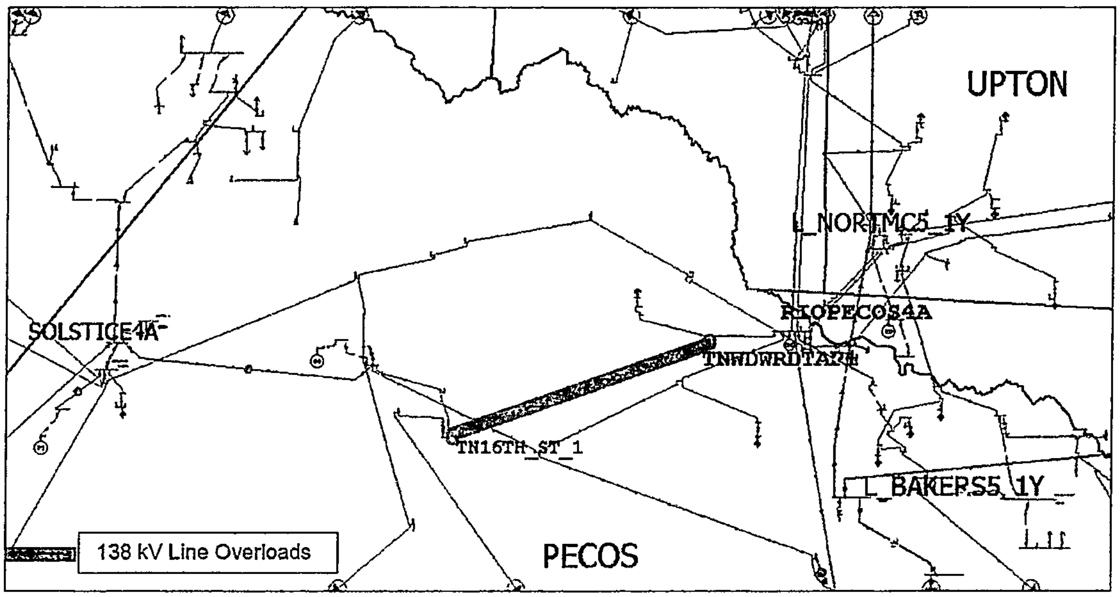


Figure 4.1: Study Case Thermal Violations in Study area

Figure 4.2 shows the voltage violations seen in the Study case.

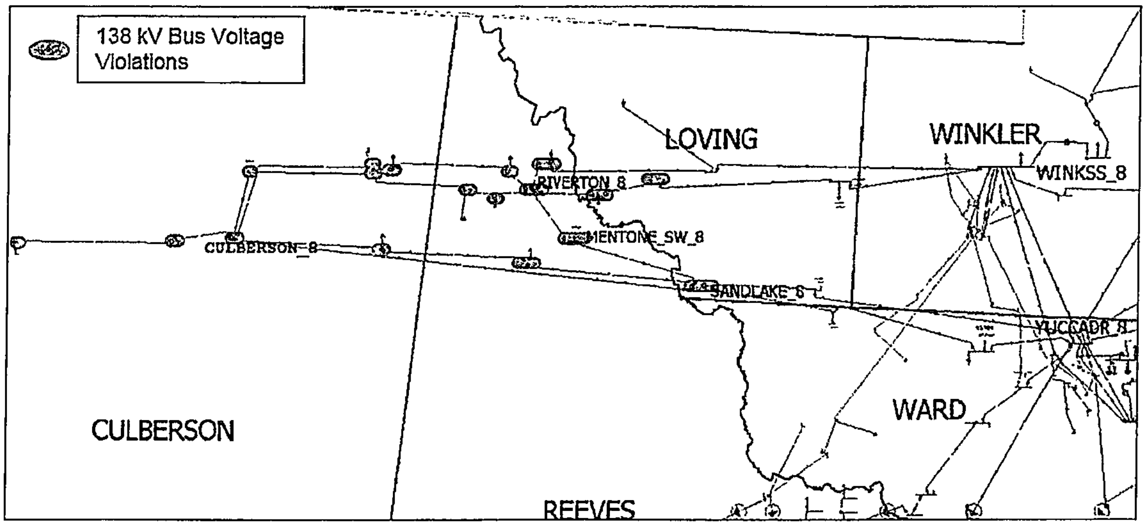


Figure 4.2: Study Case Voltage Violations in Study area

Figure 4.3 shows the thermal violations seen in the No Solar case.

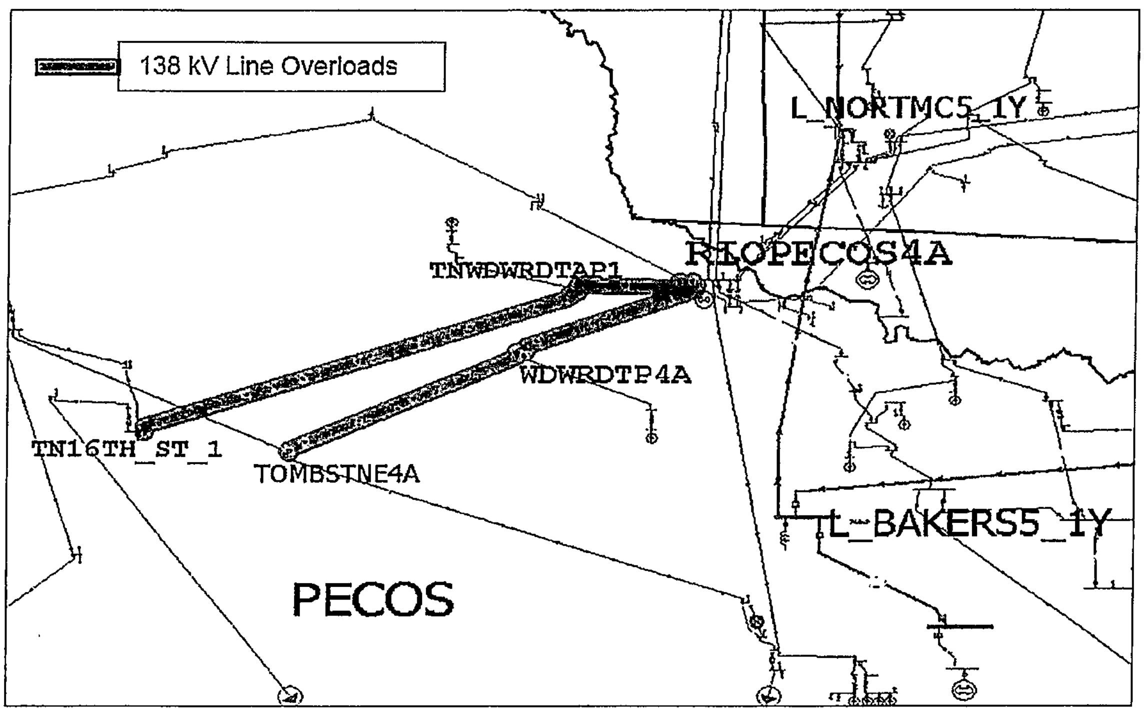


Figure 4.3: No Solar Case Thermal Violations in Study area

Figure 4.4 shows the voltage violations seen in the No Solar case.

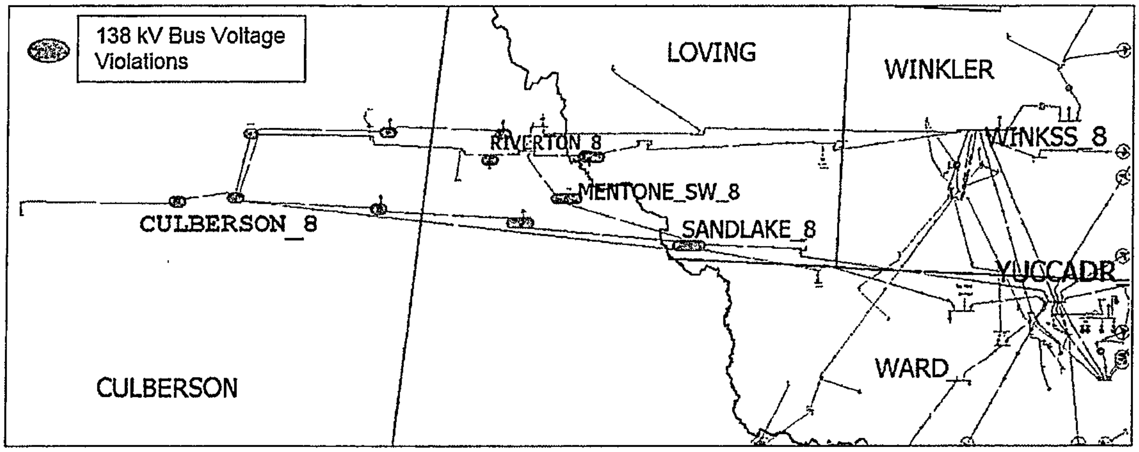


Figure 4.4: No Solar Case Voltage Violations in Study area

Both steady state and dynamic stability analyses identified reliability issues under the NERC and ERCOT reliability criteria.

5. Project Options

To address the reliability needs in the study area, ERCOT initially examined the FWTP proposal submitted by the TSPs in combination with nearly 40 alternatives.

5.1. Initial Options

An initial set of options (alternatives) was developed to address the identified reliability criteria violations for the Study Case while also considering an upgrade path to address potential needs in the future. This was accomplished by beginning with the simplest 138 kV expansion alternatives and then expanded to address performance violations. ERCOT also attempted to minimize the project cost. The ERCOT 2016 Long-Term System Assessment[2], which identified a long-term need for a project in the area, was also considered when developing the initial set of options.

The 40 alternatives could be described as variations of about 9 different transmission solutions, the variations created by using different 138 kV and 345 kV voltage class facilities; various termination points for new transmission lines; and various reactive compensation. Accordingly, diagrams of project options with cost estimates and a summary of reliability performance findings are provided in the Appendix for the 9 major transmission solutions.

Cost and reliability performance comparisons were used to narrow the 9 major solution options to the short-listed options discussed next. Generally, the short-listed options are also variations of the FWTP originally proposed by the TSPs.

5.2. Short-Listed Options

Among all the initial options, a final number of four options were studied further. The detailed description of the four short-list options are provided below and diagrams for these are included in the Appendix.

- **Option 1**
  - Install a new 200 MVAR Dynamic Synchronous Condenser at Mentone 138 kV substation
  - Install a new 200 MVAR Dynamic Synchronous Condenser at Culberson 138 kV substation
  - Construct a new approximately 85-mile 345 kV line operating at 138 kV on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV to create the new Odessa EHV - Riverton 345 kV line operating at 138 kV.
  - Build a new McCamey – Fort Stockton 345 kV double circuit line operating at 138 kV (requiring approximately 47-miles of new Right of Way)
  - Build a new Pig Creek – Fort Stockton 345 kV single circuit line operating at 138 kV (requiring approximately 39-miles of new Right of Way)
  - Install a new 50 MVAR capacitor bank each at Mentone and Salt Creek 138 kV substations

[2] http://www.ercot.com/content/wcm/lists/89476/2016_Long_Term_System_Assessment_for_the_ERCOT_Region.pdf

- Install a new 18 MVAR capacitor bank each at Orla, Elmar, Loving and Alamito Creek 138 kV substation
- Install a new 3.6 MVAR capacitor bank Espy Wells 69 kV substation
- Install a new 10.8 MVAR capacitor bank at Shafter Goldmine 69 kV substation
- Install a new 7.2 MVAR capacitor bank at Sanderson TNP 69 kV substation

The total cost estimate for Option 1 is approximately $464 Million.

- **Option 2**
  - Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV to create the new Odessa EHV – Riverton 345 kV Line
  - Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 68-mile 345 kV line from Solstice Switch Station to Bakersfield station on double-circuit structures with one circuit in place

The total cost estimate for Option 2 is approximately $336 Million.

- **Option 3**
  - Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV to create the new Odessa EHV – Riverton 345 kV Line
  - Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Expand the Sand Lake Switch Station to install a 345 kV ring-bus arrangement with one 600 MVA, 345/138 kV autotransformer
  - Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 41-mile 345 kV line on double-circuit structures with one circuit in place, Sandlake – Solstice 345 kV single circuit line (requiring approximately 41 miles of new Right of Way).
  - Add a second circuit to the Riverton – Mentone – Sand Lake 345 kV to create a Riverton – Sand Lake 345 kV line on the existing Riverton – Mentone – Sandlake 345 kV line operating at 138 kV.

- Construct a new approximately 68-mile 345 kV line from Solstice Switch Station to Bakersfield station on double-circuit structures with one circuit in place

The total cost estimate for Option 3 is approximately $446 Million.

- **Option 4**
  - *Option 4 is same as Option 3 with an additional new 200 MVAR Synchronous* Condenser at Culberson 138 kV substation.

The total cost estimate for Option 4 is approximately $501 Million.

6. Steady-State Performance of Short-listed Options

To compare and contrast each of the options several analyses were performed. This Section discusses the performance of the four short-listed options under N-1 (NERC P1, P2-1 and P7) steady state contingency conditions for the studied scenarios.

Table 6.1 Steady State Reliability Assessment of All Final Options under N-1 (NERC P1, P2-1 and P7)

Load Level	Violation Type	Case	Option 1	Option 2	Option 3	Option 4
Study Case (533 MW in Culberson loop; 511 MW in Barilla Junction area)	Thermal	With Solar	No Violations	No Violations	No Violations	No Violations
		No Solar	No Violations	No Violations	No Violations	No Violations
	Voltage	With Solar	No Violations	No Violations	No Violations	No Violations
		No Solar	No Violations	No Violations	No Violations	No Violations
Potential Load Case (810 MW in Culberson loop; 568 MW in Barilla Junction area)	Thermal	With Solar	*Violations*	*Violations*	No Violations	No Violations
		No Solar	*Violations*	*Violations*	No Violations	No Violations
	Voltage	With Solar	No Violations	*Violations*	No Violations	No Violations
		No Solar	No Violations	*Violations*	No Violations	No Violations

The steady state results showed that all of the four options addressed the reliability needs in the Culberson loop and Barilla Junction area with Study Case load conditions. In the Potential Load scenario there were violations for Options 1 and 2. Option 3 and 4 showed no violations even under the Potential Load scenario. Option 3 had a voltage deviation of over 8% at Orla 138 kV substation in the Potential Loads case. It should be noted that there were some violations that were more severe in the cases that had solar generation than in the No Solar scenarios as these cases all reflected summer peak loading conditions while the No Solar cases had a slightly lower load level. A complete list of branch and voltage violations and the corresponding contingencies are provided in the Appendix.

7. Voltage Stability Analysis

A voltage stability analysis was conducted for the Culberson loop area for all short-listed options. The No Solar scenario represents the most stressed system condition from a voltage stability perspective and was therefore tested for all of the short-listed options. A Power-Voltage (PV) stability assessment was used to proportionally increase the load in the Culberson loop until a voltage collapse identified the maximum load-serving capability for these options. The PV analysis included NERC P1, selected P6, and P7 contingency events. Table 7.1 shows the maximum load in the Culberson loop area to be reliably served as identified in the voltage stability analysis. All of the short-listed options provide more than a 10% voltage stability load margin when compared to the Study Case load level.

Table 7.1 Voltage Stability Assessment of All Final Options

Description	Option 1	Option 2	Option 3	Option 4
PV Results Culberson loop Load Served (MW)	917	717	917	1037

8. Economic Analysis

Although this RPG project is driven by reliability needs, ERCOT also conducted an economic analysis to compare the relative performance of each of the final options in terms of production cost savings.

The base case for this economic analysis used the 2022 economic case built for the 2016 RTP as the starting case. The topology changes and generation additions were similar to the steady state base case built. The load was modified to reflect the demand in the RPG proposal, but a 50/50 load scenario was used in ERCOT economic analysis, whereas the steady state analysis used a 90/10 load scenario. ERCOT modeled each of the four final options and performed production cost simulations for the year 2022. The annual production cost under each select option was compared to the option yielding the highest annual production cost in order to obtain a relative annual production cost saving for each option.

As shown in Table 8.1, the results indicates that Options 2 to 4 have over $6 million annual production cost savings compared to Option 1. This relative improvement in savings is due to the loss savings achieved by operating the new transmission lines at 345 kV. This apart, Options 2 to 4 showed no significant difference in congestion.

Table 8.1 Relative annual production cost savings (referenced to Option 1), in $ Million

Option	Option 1	Option 2	Option 3	Option 4
Relative Annual Production Cost Savings (referenced to Option 1)	-	6.2	6.6	6.6

9. Final Options Comparison

As shown in Table 9.1, a comparison of study results for the short-listed options shows that Option 2 met the system reliability criteria under the Study Case load conditions while deferring more than $100 million in capital expenditures when compared to the other options. Option 2 also resulted in lower system production costs when compared to Option 1 and was expected to provide an adequate voltage stability margin.

Although Option 2 did not meet the system reliability criteria for the Potential Load scenario, there are a number of different expansion options that can augment the load serving capability of Option 2 as the outlook for greater load and generation resources in this region becomes more certain. More specifically, as indicated by these studies, Option 3 or 4 are two possible options that could be constructed from Option 2 to meet applicable transmission planning criteria while serving significantly higher loads in this region. Option 2 also aligns with the long-term needs identified for the area in the 2016 Long-Term System Assessment.

Table 9.1 Options Comparison

Description	Option 1	Option 2	Option 3	Option 4
System Performance – Study Case	Met criteria	Met criteria	Met criteria	Met criteria
System Performance – Potential Load Case	Criteria not Met	Criteria not	Met criteria	Met criteria
Capital cost ($ Million)	464	336	446	501
PV Results Culberson Load Served (MW)	917	717	917	1037
Relative Production Cost Savings ($ Million)	-	6.2	6.6	6.6
Total System Loss Reduction (MW)	10.4	31.2	34.4	34.4
New Right of Way Required (Miles)	187	169	235	235

Additional studies were performed to verify that Option 2 will provide the most cost-effective configuration to meet the Study Case load conditions consistent with ERCOT Protocol and Planning Guide requirements.

9.1. Final Steady-State Performance Test

NERC P3, P6-1, P6-2 and P6-3 contingency analyses were performed under the Study Case load conditions with Option 2. This Option had no voltage collapse for these contingencies at the Study Case load level with both base case generation and with No Solar conditions applied.

Additionally, P2.2-2.3 (EHV), P4.1-P4.5 (EHV) and P5 (EHV) contingencies for the West and Far West Weather Zones were applied to Option 2 using the Study Case load levels with the base case generation and with No Solar conditions applied. There were no criteria violations found for Option 2 based on the conditions studied.

Figure 9.1 shows Option 2 applied to the study area.

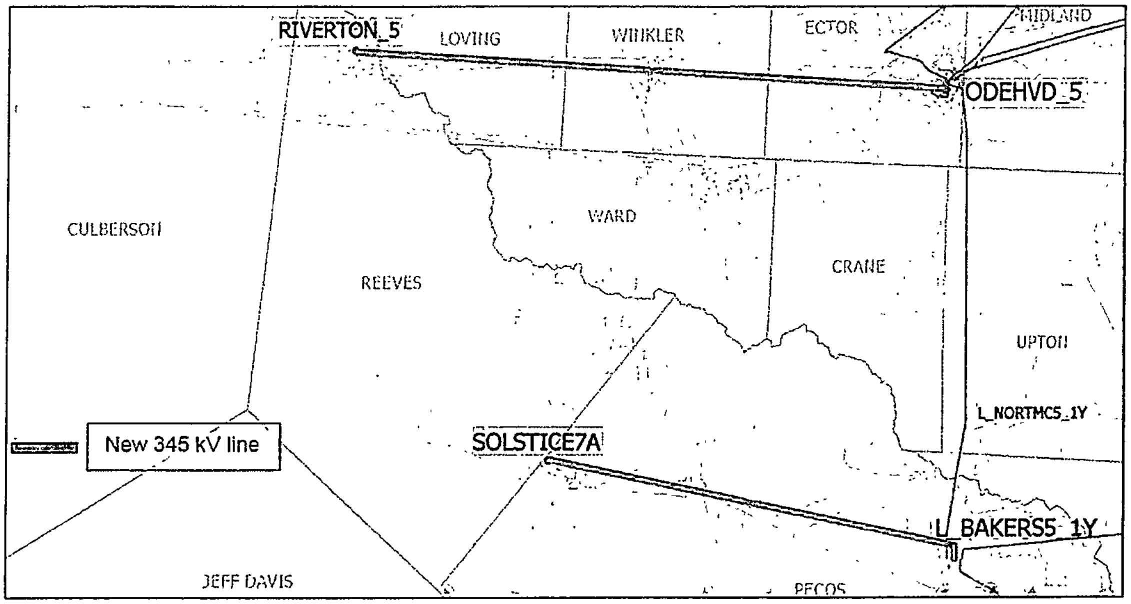


Figure 9.1: Option 2 applied to the Study area

9.2. Dynamic Performance

The majority of the loads in the study area were assumed to be oil and gas customers who employ voltage sensitive electric equipment in their operations. As indicated by the TSPs, heavy motor load was assumed to represent the load characteristic in the study area. The preferred Option 2 was tested using time domain dynamic stability simulations including a dynamic load model to quantify system stability.

It was assumed that if simulations indicated an acceptable (stable) system response following severe events and/or three-phase faults, the stability response would also be acceptable for the same events with single-line-to-ground (SLG) fault. If a potential stability issue was observed, the simulation was rerun with SLG faults to ensure a stable system response following a NERC planning events when applicable, thereby demonstrating compliance with NERC planning standards and ERCOT reliability criteria. Selected ERCOT transmission buses were monitored for frequency and voltage deviations. Nearby synchronous generating units were monitored for angular separation.

The limiting events identified in the PV analysis were studied in the dynamic simulation.

The dynamic event definitions included the removal of all elements that the protection system and other automatic controls are expected to disconnect for each event.

The dynamic simulation results showed that with Option 2 upgrades implemented the area of concern met the NERC and ERCOT reliability criteria. Detailed dynamic simulation results are presented in the Appendix.

10. Sensitivity Studies

Sensitivity studies were performed to ensure compliance with Planning Guide requirements.

10.1. Generation Sensitivity Analysis

ERCOT performed a generation sensitivity analysis based on Planning Guide Section 3.1.3(4) (a). Generator additions with signed Interconnection Agreements but that did not meet Planning Guide Section 6.9 conditions for inclusion in the base cases at the beginning of the study in the study region were added to the Study Case (based on the 2017 March Generator Interconnection Status report). In between the October 2016 Generator Interconnection Status and March 2017 Generator Interconnection Status reports there were another five units that met Planning Guide Section 6.9 conditions. These units were also added in this sensitivity study. Table 10.1.1 and 10.1.2 show all the generators that were added to the Study Case for this analysis.

Table 10.1.1 Generators Met Planning Guide Section 6.9 Conditions (2017 March GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
14INR0044	West of Pecos Solar	100	Solar	Reeves	Far West
15INR0064	BearKat Wind A	197	Wind	Glasscock	Far West
17INR0027	Dermott Wind 1	250	Wind	Scurry	West
15INR0064b	BearKat Wind B	163	Wind	Glasscock	Far West
17INR0027b	Coyote Wind	250	Wind	Scurry	West

Table 10.1.2 Generators with SGIA That Did Not Meet Planning Guide Section 6.9 Conditions (2017 March GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
13INR0023	Texas Clean C	240	Coal	Ector	Far West
16INR0010	FGE Texas 1	745	Gas	Mitchell	West
17INR0010	FGE Texas II	799	Gas	Mitchell	West
12INR0059c	Barilla Solar 2	21	Solar	Pecos	Far West
16INR0019	Capricorn Ridge Solar	100	Solar	Coke	West
16INR0023b	Lamesa Solar B (Phase II)	98	Solar	Dawson	Far West
12INR0060	Infinity Live Oak Wind	201	Wind	Schleicher	West
16INR0086	Cactus Flats Wind	150	Wind	Concho	West
13INR0020b	Rattlesnake W2	158	Wind	Glasscock	Far West

The purpose of this generation sensitivity analysis was to evaluate the effect of the above mentioned generation units on the recommended transmission project. It was found that the Study Case violations did not entirely disappear with these additional generations. The violations seen for the Study Case with the generation units meeting Planning Guide Section 3.1.3(4) (a) criteria are summarized in Tables 10.2.1 – 10.2.4.

Table 10.2.1 Thermal Overloading in the Study Region under N-1 Conditions, With Generation meeting Planning Guide Section 3.1.3(4) (a)

Element	Length (miles)	Study Case	No Solar
16th Street TNP to Woodward2 138 kV ckt 1	31.8	No Violation	110%
Rio Pecos to Woodward2 138 kV ckt 1	1.9	No Violation	101%
Tombstone to Woodward1 Tap 138 kV ckt 1	15.7	No Violation	101%

Table 10.2.2 Unsolvable contingencies, With Generation meeting Planning Guide Section 3.1.3(4) (a)

#	Contingency (Category)	Study Case	No Solar
1	CEII	Unsolvable	Unsolvable

Table 10.2.3 Voltage Deviations in the Study Region under N-1 Conditions, With Generation meeting Planning Guide Section 3.1.3(4) (a)

Bus	Nominal Voltage (KV)	Study Case	No Solar
Wolfbone Tap TNP	138	< 8%	8.8%
Woodward 1 Tap	138	< 8%	8.7%
Woodward 1	138	< 8%	8.7%

Table 10.2.4 Voltage Violations in the Study Region under N-1 Conditions, With Generation meeting Planning Guide Section 3.1.3(4) (a)

Bus	Nominal Voltage (KV)	Study Case	No Solar
Sandlake	138	0.898	No Violation
Coalsndr	138	0.888	No Violation
Mentone SW	138	0.882	No Violation
Culberson2	138	0.881	No Violation
Screw bean Tap	138	0.878	No Violation
Kunitz	138	0.877	No Violation
Salt Creek West Poi	138	0.877	No Violation
Culberson Wind Farm	138	0.876	No Violation
Culberson	138	0.876	No Violation
Black River	138	0.871	0.899
Orla Southwest Poi	138	0.869	0.892
Riverton	138	0.869	0.896
Sand Bend Poi	138	0.867	0.895
Orla Plant	138	0.867	0.889
Salt Creek South Poi	138	0.864	0.892
Oxy Century TNP	138	No Violation	0.898
Wink TNP	138	No Violation	0.897

The above tables demonstrate the need for the transmission upgrades required to meet the NERC and ERCOT reliability criteria even with the additional generators in Tables 10.1.1 and 10.1.2. Full contingency results can be found in the Appendix.

Further analysis was performed testing these new sensitivity cases with Option 2 improvements applied. There were no criteria violations (under NERC P1, P2-1 and P7 events) seen for Option 2 with the generation sensitivity discussed in this section.

10.2. Load Scaling Impact Analysis

Planning Guide Section 3.1.3(4) (b) requires evaluation of the impact of various load scaling on the criteria violations seen in the study cases. As stated in Section 3.1.1, ERCOT used the 2021 West/Far West (WFW) summer peak case from the 2016 RTP for the steady state analysis. This case was created in accordance with the 2016 Regional Transmission Plan Study Scope and Process document[3], which included load scaled down from the respective non-coincident peaks forecasted in the North, North Central, East, Coast, South, and South Central Weather Zones.

There were four 138 kV thermal violations seen in the steady state analysis as described in Section 4.1 of this report. Power Transfer Distribution Factors (PTDFs) were calculated using PowerWorld Simulator for these four lines using the Far West Weather Zone as the sink, and each of the other seven weather zones individually as the sources. It was found that no matter which other zones were scaled, the PTDFs for each of the lines remained very close. Therefore, ERCOT concluded that the load scaling applied in the cases did not affect the study results. The Appendix contains the PTDFs for each of the four lines under various transfers.

Because the voltage violations were observed at load serving buses, ERCOT assumed that the load scaling in the outside weather zones did not have a material impact on the observed need.

The case used in the dynamic stability portion of the analysis did not contain load scaling, therefore, the observed criteria violations were not affected by load scaling.

[3] http://www.ercot.com/content/wcm/key_documents_lists/77730/2016_RTP_Scope_Process_v1.3_clean.pdf

11. Conclusion

Based on the forecasted loads and scenarios analyzed, ERCOT determined that there is a reliability need to improve the transmission system in Far West Texas. After consideration of the project alternatives, ERCOT concluded that the upgrades identified in Option 2 meet the reliability criteria in the most cost effective manner and have multiple expansion paths to accommodate future load growth in the area of study. Option 2 is estimated to cost $336 million and is described as follows:

- Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer.
- Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV Switch Station. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV Switch Station to create the new Odessa EHV – Riverton 345 kV Line.
- Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer.
- Construct a new approximately 68-mile 345 kV line from Solstice Switch Station to Bakersfield Station on double-circuit structures with one circuit in place.

12. Designated Provider of Transmission Facilities

In accordance with the ERCOT Nodal Protocols Section 3.11.4.8, ERCOT staff is to designate transmission providers for projects reviewed in the RPG. The default providers will be those that own the end points of the new projects. These providers can agree to provide or delegate the new facilities or inform ERCOT if they do not elect to provide them. If different providers own the two ends of the recommended projects, ERCOT will designate them as co-providers and they can decide between themselves what parts of the recommended projects they will each provide.

Oncor owns the Odessa EHV Switch Station and the planned Riverton Switch Station. Therefore, ERCOT designates Oncor as the designated provider for the 345 kV Odessa EHV Switch Station to Riverton Switch Station transmission facilities along with the two recommended 345/138 kV autotransformers at Riverton Switch Station.

LCRA TSC owns the Bakersfield Station and AEP Texas owns the Solstice Switch Station. Therefore, ERCOT designates AEP Texas and LCRA TSC as the designated co-providers for the 345 kV Bakersfield Station to Solstice Switch Station transmission facilities along with the two recommended 345/138 kV autotransformers at Solstice Switch Station.

13. Appendix

13.1. Base Case Violations – Steady State	BaseCaseViolations.xlsx
13.2. Options Diagrams	Options_Diagrams.pptx
13.3. Steady State Violations of Project Options	ProjectOptionsViolations.xlsx
13.4. Violations – Generation Sensitivity Analysis	GenerationSensitivityAnalysisViolations
13.5. Dynamic Analysis Results	CEII

FAR WEST TEXAS PROJECT

ERCOT REGIONAL PLANNING GROUP PROJECT SUBMITTAL FOR REVIEW

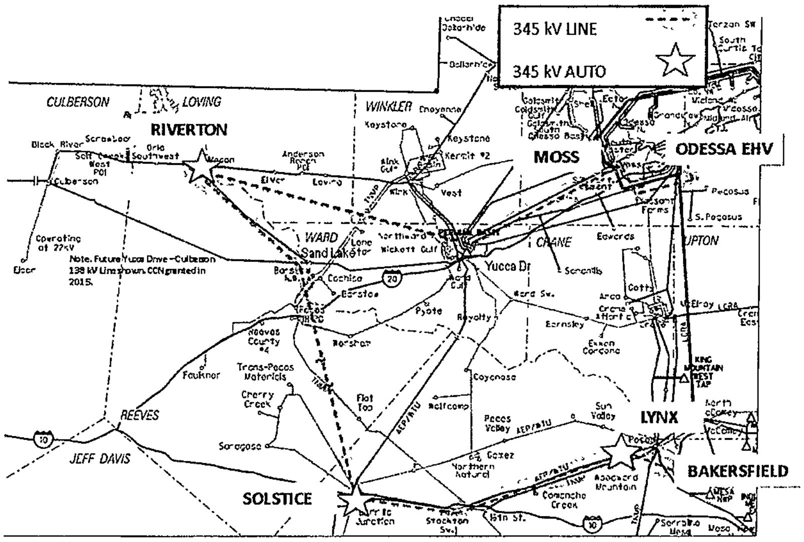
April 20, 2016

AMERICAN ELECTRIC POWER SERVICE CORPORATION
ONCOR ELECTRIC DELIVERY COMPANY CO LLC

Table of Contents

Executive Summary

This report describes the purpose and necessity to construct the Far West Texas Project (FWTP). The FWTP consists of a 345 kV line from Odessa to Moss to Permian Basin to Mason to Pecos to Barrilla to Fort Stockton to Rio Pecos to Bakersfield; with the initial installation of 345/138 kV autotransformers at Riverton, Solstice and Lynx stations. The estimated total cost of the project is $423 million with an in-service date of 2022 or sooner. It also provides for longer term growth in the Region by allowing for the future addition of a second 345 kV circuit and additional autotransformer installations. This is a joint project of American Electric Power Service Corporation (AEP) and Oncor Electric Delivery Co LLC (Oncor). We are requesting that ERCOT and the Regional Planning Group (RPG) consider and review this proposed project to address transmission constraints and needs.



AEP and Oncor continue to monitor West Texas load growth due to oil and natural gas production, transportation, mid-stream processing, and associated support activities in the Permian Basin. The Delaware Basin remains very active and significant load growth is resulting in the need for the addition of new transmission infrastructure in areas where little existed previously.

Additionally, AEP and Oncor continue to monitor new generation interconnection requests in the region. The Barrilla Junction Area southwest of Odessa remains very active with solar generation developments that will require additional transmission capacity and support.

The Far West Texas Project is needed to:

- Provide reliable service to current and future load
- Relieve planning criteria violations including overloading and voltage collapse with loss of load
- Support continuing oil/natural gas load growth and new generation interconnections
- Provide injection sources to aid short circuit strength limitations and meet system protection requirements
- Increase transmission operational flexibility under various normal and contingency conditions
- Provide a path for long-term upgrades to the region

AEP and Oncor are proposing and seeking endorsement of the FWTP which is proposed to be fully completed by 2021 to 2022. This date may change based on uncertainty in the timing of certification, environmental assessment, land acquisition, critical project status and/or other requirements.

Introduction

This report describes the need to construct the approximately 219-mile Far West Texas Project (FWTP) in Ector, Reeves, Pecos, Ward, and Winkler Counties.

The need to expand transmission facilities in West Texas is driven by increasing load due to the oil and natural gas industry and by solar generation development. Horizontal drilling technology has expanded production in the Permian Basin and resulted in increased electric demand to meet the requirements of oil and natural gas field operations, mid-stream processing, and a growing local economy. Much of this activity focuses on one of the largest reservoirs known as the Delaware Basin, and shown below in Figure 1.

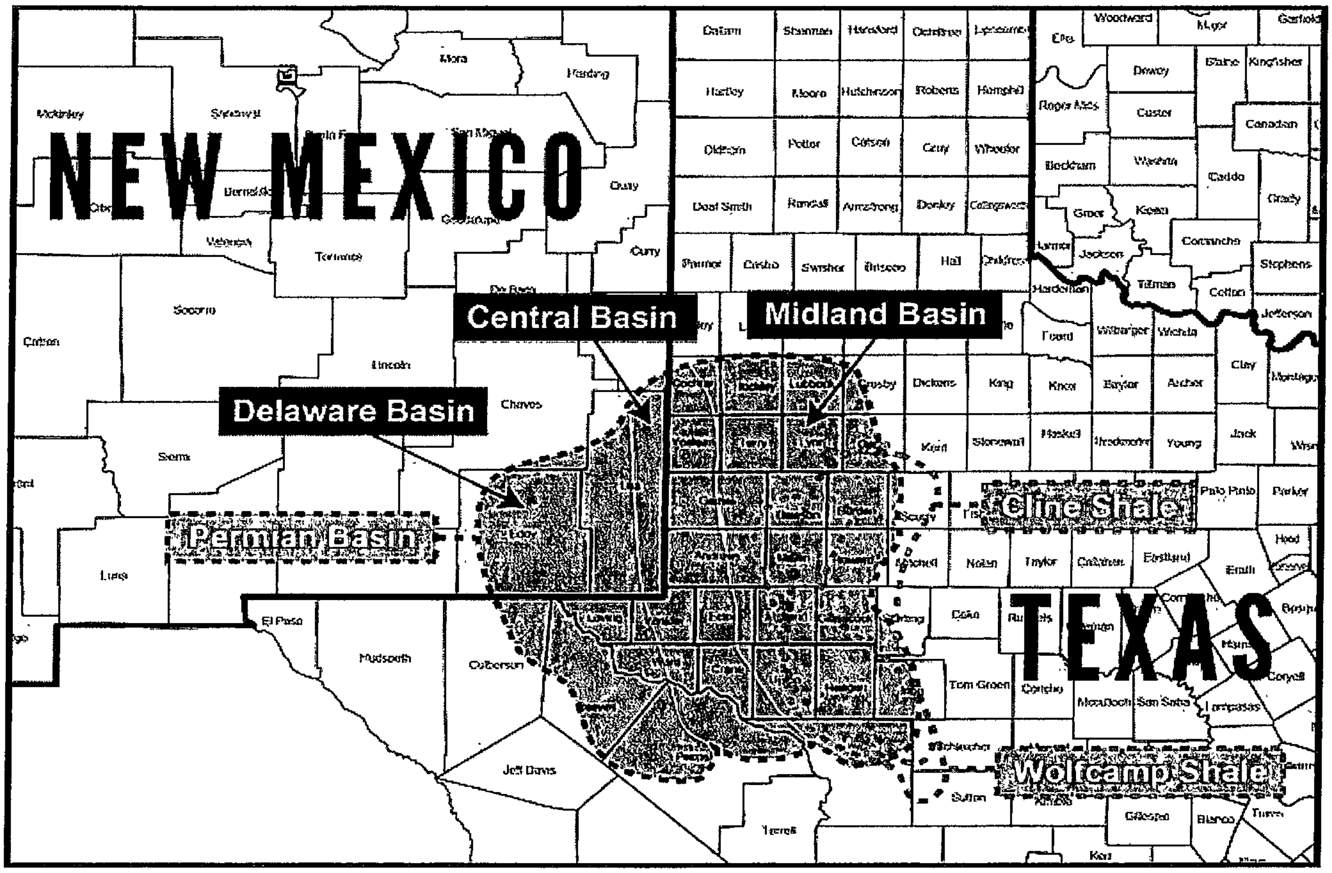


Figure 1 – Location of Delaware Basin

The loads in the Delaware Basin area are served by three Transmission Service Providers (TSPs) including Oncor, AEP, and Texas New Mexico Power (TNMP). All TSPs continue to support this growth with local area projects including the upgrade of existing transmission lines, installation of new and upgraded autotransformers, the conversion of the 69 kV system to a stronger 138 kV service, the installation of reactive devices, and the addition of substation capacity.

Oncor recently completed rebuilding the 138 kV line sections between Mason Substation and Screwbean Substation, which is part of a 74-mile radial line that extends from the Wink Switching Station (Sw. Sta.) to the Culberson 138 kV Sw. Sta. in Culberson County. The remaining 138 kV line section between Screwbean Substation and Culberson is planned for reconstruction by the end of 2017. Oncor will also begin construction on the new Yucca Drive – Culberson 138 kV Line in 2016. Yucca Drive is a new switching station near the Permian Basin Sw. Sta. located in Ward County. The new line will complete a 138 kV loop from Wink to Culberson and back to Yucca Drive (The Wink – Culberson – Yucca Drive Loop). In support of this Loop, Oncor recently submitted the new Riverton – Sand Lake 138 kV Line proposal to the ERCOT RPG.

AEP and Oncor also recently submitted the Barrilla Junction Area Improvement Project proposal to the ERCOT RPG, which includes rebuilding the Yucca Drive – Barrilla Junction 138 kV Line. The area southwest of Odessa, served by the 69 kV and 138 kV lines between Permian Basin, Barrilla Junction, Fort Stockton Plant, and Rio Pecos stations (The Barrilla Junction Area) has seen an increased interest in solar generation development.

While these previously submitted projects are effective in addressing local issues, they provide limited improvement on a larger scale and do not provide a new transmission source, a 345 kV source, to satisfy the growing load and the interconnection needs of new generation in the Far West Texas area. Both the previously submitted 138 kV projects and the FWTP needed as part of the long-term plan in West Texas .

The location of the FWTP and surrounding transmission system is shown below in Figure 2. The respective areas of The Wink – Culberson – Yucca Drive Loop and The Barrilla Junction Area are shown within the blue circles.

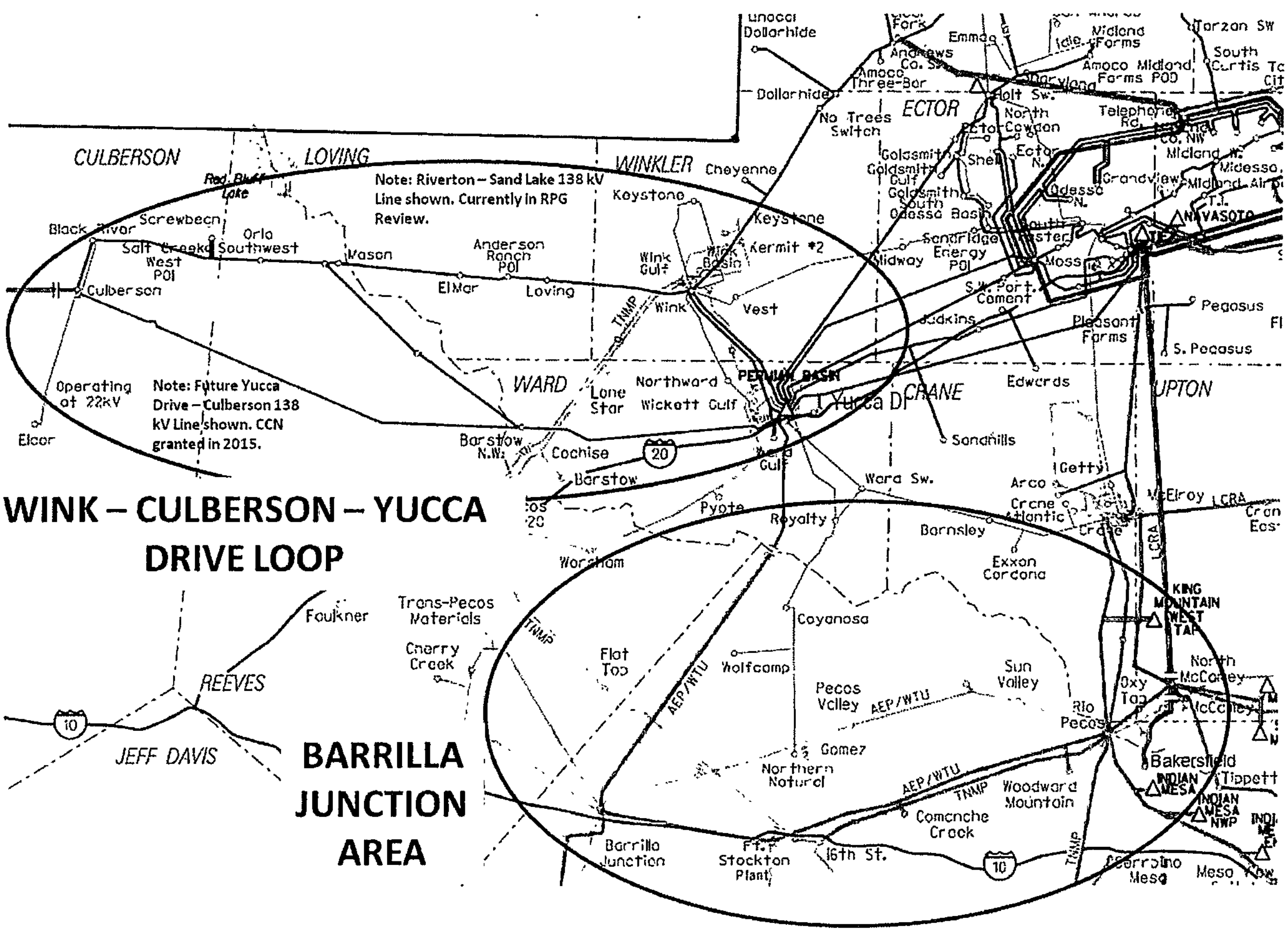


Figure 2 – Location of the Far West Texas Project

Purpose and Necessity

Load Growth

The electric load in West Texas has grown dramatically over the last several years. This load growth is continuing due to the oil/natural gas industry and supporting businesses. Recent improvements in oil and natural gas horizontal drilling technologies have increased activity in the area, resulting in major load growth at existing substations and the need for new substations to serve the added load in Far West Texas. Despite declining oil prices over the last 18-24 months, AEP and Oncor have continued to experience increased loads in this area compared to historical load levels. This increase in oil and natural gas production, transportation and mid-stream processing has resulted in economic growth in the area that is supporting the industry. Figure 3 below shows the growing load in the area despite a production drawback in the Permian Basin.

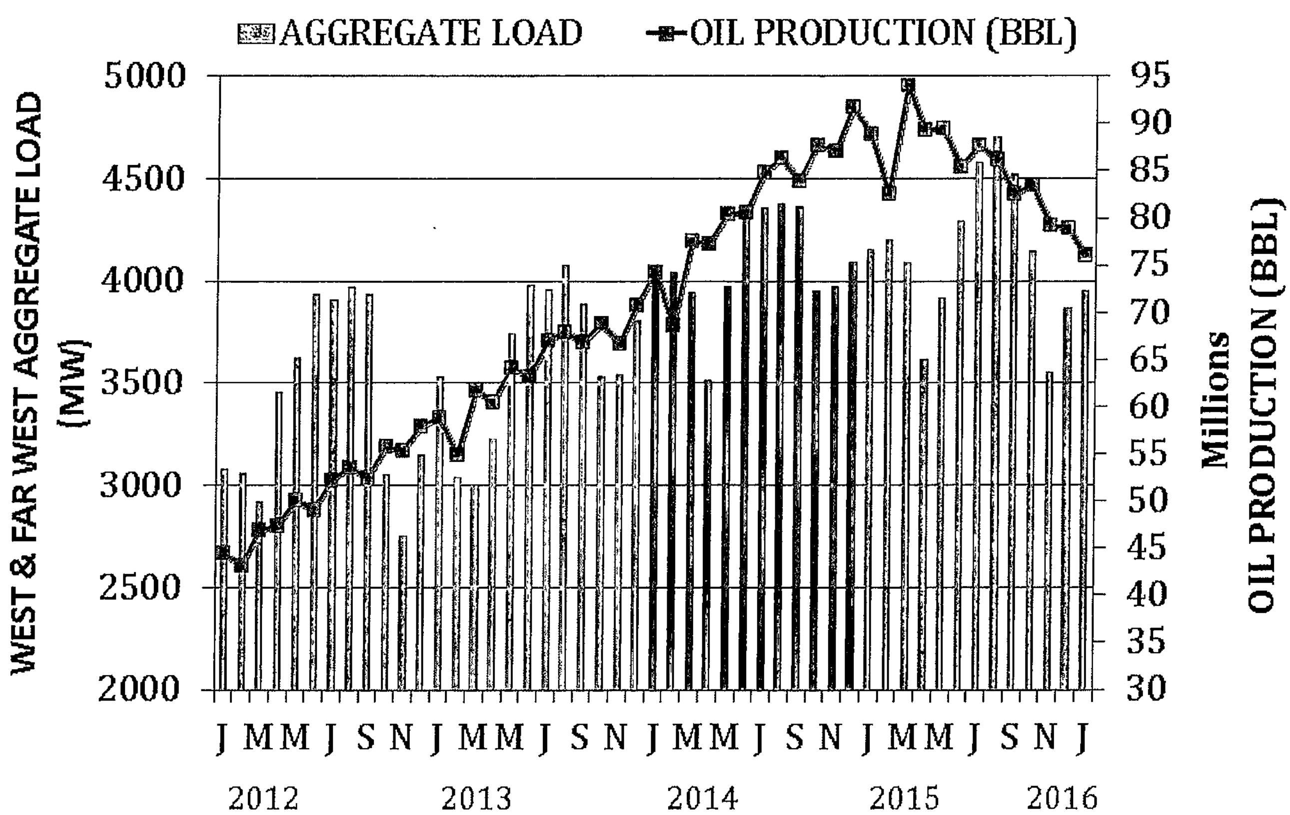


Figure 3 – Growing Aggregate Load vs. Oil Production

While the oil and natural gas production levels have recently leveled, the business friendly environment of Texas, existing infrastructure, and the geological characteristics of the Permian Basin make it a prime candidate to be the first oil and natural gas area that returns to high growth levels. Additionally, developing improvements in horizontal drilling technologies are resulting in improvements in efficiencies, speed, and service cost reductions which will only improve horizontal well margins and economics as time progresses. More background info and data is available from the link below for the "Oil and Gas Seminar – An Education on the Permian Basin Production and Processing Techniques" held November 10, 2015 at ERCOT in Austin, TX.
http://www.ercot.com/calendar/2015/11/10/76898-WORKSHOPS

Secondary facilities that follow and support production, including midstream processing plants, also create a challenge for area TSPs as they are large amounts or "blocks" of load, sometimes 40 to 100 MW located 50 to 100 miles apart. The inherent nature of midstream facilities results in wide variations in electrical power needs and geography, allowing for little predictability or transparency into exact locations for these developments, other than being regionally located with production fields. The need for transmission facilities to adequately serve these types of midstream facilities is critical since such large loads can have large, stressing impacts on transmission system capacity and voltage.

The FWTP is located in the Delaware Basin, a highly active area for drilling for oil and natural gas in the western portion of the Permian Basin. The electrical summer peak load for Oncor counties within the Delaware Basin, including Culberson, Reeves, Loving, Ward and Winkler Counties grew at an annual rate of approximately 13% from 2012 to 2015. Oncor's expected annual growth for the area will average 11% over the next five years and 7.0% over the next 10 years.

The table below shows the sum of historical and projected summer peak loads (MW) for The Wink – Culberson – Yucca Drive Loop. The loads from 2010 to 2015 are actual summer peaks (MW), and the loads for 2016 to 2021 are projected summer peaks (MW) from the 2016 Annual Load Data Request (ALDR). These projections only include confirmed load increases from normal load forecasting and signed customer agreements. There are other active inquiries to connect additional customers in the area, but the load associated with these requests has not been included in Table 1.

	Historical Load						Projected Load					
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total (MW)	22.4	21.6	33.4	53.2	89.7	105.4	231	304	343	391	411	426

Table 1- Historical and Projected Load (MW) Served from the Wink – Culberson – Yucca Drive Loop

Currently AEP projects over 350 MW of summer peak load for The Barrilla Junction Area. With the oil and natural gas activity in the area, AEP anticipates that The Barrilla Junction Area load will grow to over 500 MW by 2021 with over 160 MW being served by the Yucca Drive – Barrilla Junction 138 kV Line alone. Table 2 below shows the sum of projected summer peak loads (MW) being served by the Barrilla Junction Area transmission lines.

	2016	2017	2018	2019	2020	2021
Total (MW)	387	454	483	487	490	511

Table 2- Projected Load (MW) Served from the Barrilla Junction Area Lines

Oncor studies have shown that as load increases in the Delaware Basin on The Wink – Culberson – Yucca Drive Loop, additional projects will be needed to adequately serve the load. AEP studies have shown that after the Barrilla Improvement Transmission Project, additional thermal issues will exist on the two 138 kV paths between Barrilla Junction/Solstice and Rio Pecos. Additional transmission infrastructure improvements will be needed to reliably serve growing load in the region.

Generation Growth

The Barrilla Junction Area is under increased interest for solar generation development. As of April 2016, more than 7,700 MW of solar development projects are currently in the ERCOT generation interconnection process, most of which are concentrated in the West and Far West weather zones of West Texas where transmission infrastructure is either relatively weak or no infrastructure exists.

Currently there is over 1,650 MW of renewable generation in The Barrilla Junction Area including a 160 MW wind facility (Woodward Mountain) that is interconnected west of Rio Pecos. There is approximately 850 MW of conventional generation north of the Barrilla Junction Area at Permian Basin SES, Odessa Ector, and Quail. Figure 4 below shows The Barrilla Junction Area and surrounding generation.

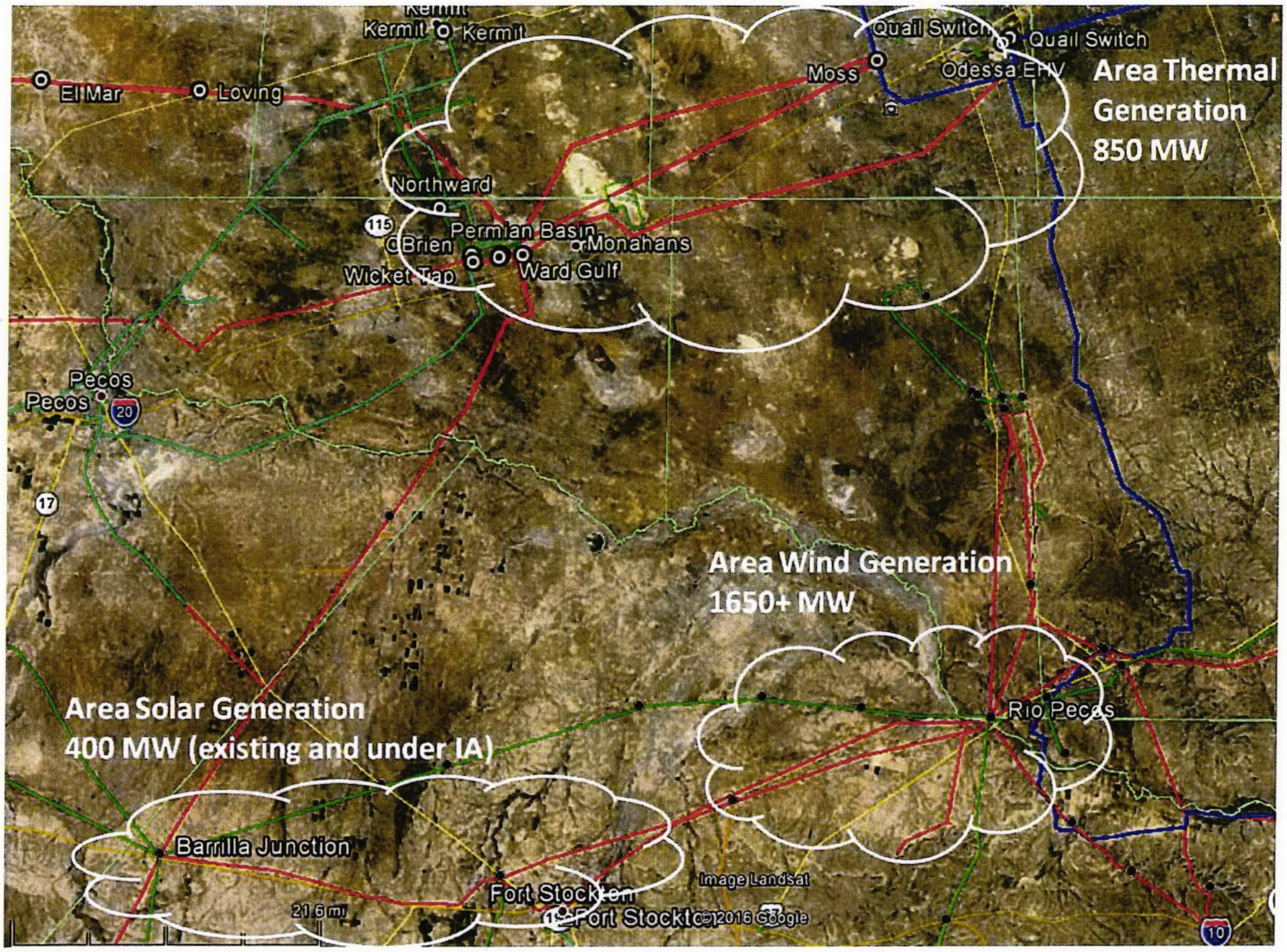


Figure 4- Barrilla Junction Area and Surrounding Generation

Both AEP and Oncor have received multiple inquiries for generation interconnects in the region. Based on the March 2016 ERCOT Transmission Generation Interconnect Project list, there are 27 projects in the planned status in the FWTP's surrounding counties of Culberson, Pecos, Reeves, and Winkler counties totaling 3,380 MW of new generation. New solar generation developments account for 25 of the 27 projects.

Oncor has 5 requests in the study queue for generation interconnects in the FWTP's surrounding area, totaling 758 MW of new generation. New solar generators represent 4 of the 5 requests, totaling 635 MW.

AEP has approximately 1,000 MW in signed interconnect agreements (IAs) with solar generators that are connecting in Pecos, Reeves, and Upton counties with approximately 400 MW connecting directly on the 138 kV and 69 kV transmission system in the Barrilla Junction Area. In addition, AEP has an additional 1,000 MWs of generation in the study queue.

The solar generation facilities in The Barrilla Junction Area include:

- Barrilla Solar (50 MW) located just west of the existing Barrilla Junction 138 kV Station
- Rose Rock (150 MW) that has an executed IA and is under construction which will interconnect at the Barrilla Junction/Solstice Station
- Oak Solar (150 MW) that has an executed IA and will be connected to the Fort Stockton Plant 138 kV Station
- Solaire Holman (50 MW) that has an executed IA and will be connected to the Ft. Stockton Plant – Alpine 69 kV Line
- East Pecos Solar (120 MW) that has an executed IA and will be connected at Bakersfield 345 kV Station
- Maplewood Solar (500 MW) that has an executed IA and will be connected at Bakersfield 345 kV Station

AEP studies indicate that the transmission lines in The Barrilla Junction Area will be close to their maximum transfer capability with the interconnection of these future solar generation facilities. As a result, transmission infrastructure improvements will be needed in the region to support future solar development. With Federal Investment Tax Credits extended, solar and other renewable generation developments in the area are expected to continue.

The Far West Texas Project satisfies existing and anticipated reliability needs, creates new pathways for new generation to access the 345 kV transmission system, increases transfer capacity, and enables reliable transfer to load centers. Completion of the FWTP also provides greater flexibility in conventional generation dispatch, which should help address congestion in the area.

Oncor Studies

Oncor studies identified certain outages on The Wink – Culberson – Yucca Drive Loop that result in unacceptable system conditions. The worst contingency in this region is loss of the Wink – Loving 138 kV line section, which causes the remaining line sections looking toward Culberson and Yucca Drive to be insufficient to maintain adequate system operating conditions, resulting in an unsolved contingency during power flow analysis. The unsolved contingency shows an inability of the power system to maintain stable bus voltages following a disturbance or deviation from its initial operating condition. These unacceptable voltage conditions in the area will increase as load on The Wink – Culberson – Yucca Drive Loop rises to even higher levels.

Upon seeing these issues, Oncor began development and completion of several projects in the area. In addition to completing the rebuild of the existing Wink – Culberson 138 kV Line, Oncor has plans to install a shunt capacitor at Castile Hills and install second circuits on both the Wink – Culberson and the new Yucca Drive – Culberson 138 kV lines. In addition to installing double-circuits on The Wink – Culberson – Yucca Drive Loop, Oncor will relocate some substations onto the new second circuits in order to help voltage regulation and further diversify line loading. Support is also provided by the addition of the Riverton – Sand Lake 138 kV Line currently under review by the ERCOT RPG.

While these projects would initially help support system voltages pre- and post-contingency, additional voltage support will be needed in the area as the load continues to grow. Dynamic stability studies indicate additional improvements are needed in the area in order to support system voltage levels and increase system strength.

Below in Figure 5, the worst single-circuit branch outage voltage plot is shown with all the previously mentioned projects in place. The Wink – Culberson – Yucca Drive Loop voltage response is able to stabilize to acceptable levels, however delayed voltage recovery is evident, which could cause problems for customer load, particularly those of oil and natural gas customers. The simulation assumed heavy motor load, typical of oil and natural gas load in the area, using a 2019 base case.

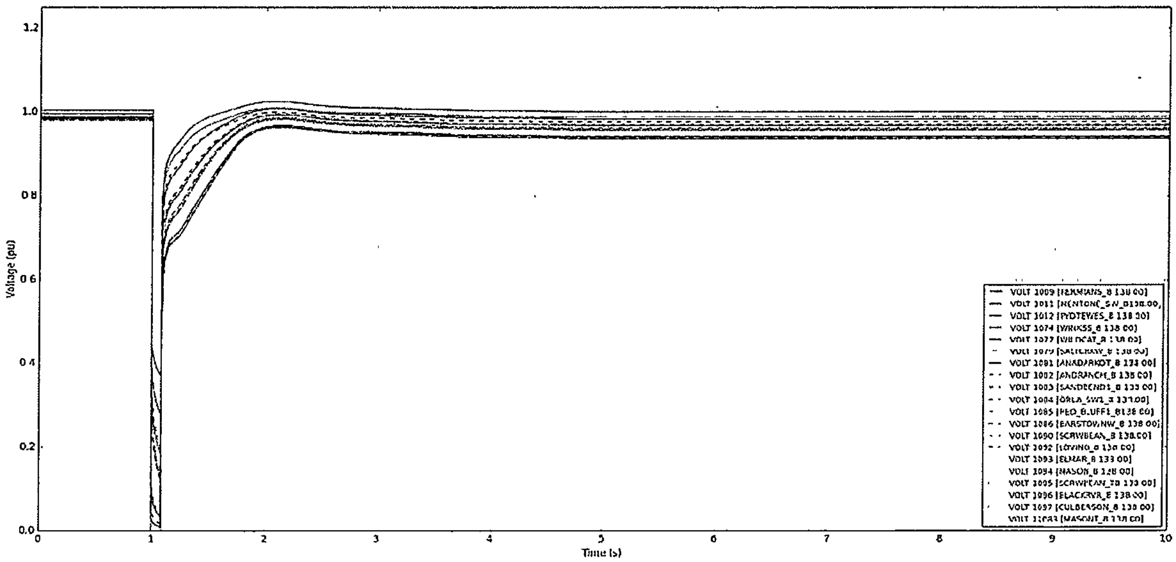


Figure 5 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for Worst Single-Circuit Branch Outage

The majority of the loads on these lines serves oil and gas customers who employ voltage sensitive electric equipment in their operations. For example, many customers are using electric submersible pumps (ESP) as the artificial lift technology for wells. This type of load operates continuously (24 hours/day, 7 days/week) under normal conditions and maintains a high load factor.

With certain double-circuit branch outages, The Wink – Culberson – Yucca Drive Loop is unable to recover to normal levels, which does not meet the ERCOT voltage recovery criteria in the Planning Guide. Figure 6 below shows voltage response under this scenario with the same base case assumptions.

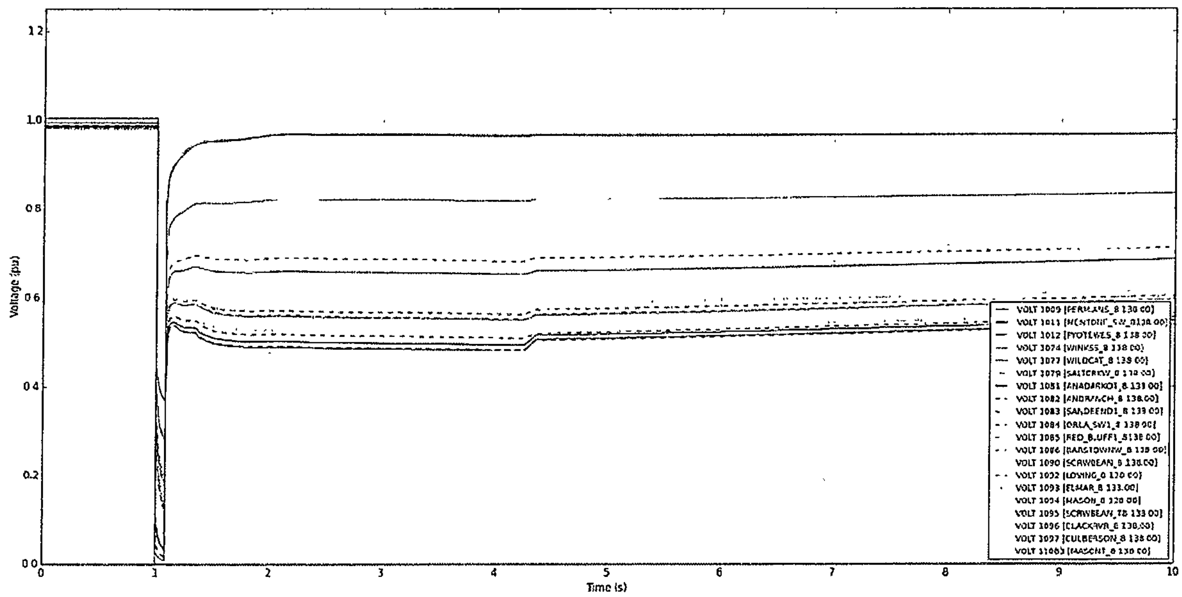


Figure 6 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for Worst Double-Circuit Branch Outage

Certain contingencies beyond NERC requirements can result in consequential load loss or result in a radial 138 kV transmission line exceeding 100 miles in length. Although these contingencies are beyond base planning requirements, the severe consequences merit consideration. The resulting transmission system is skeletal and fragile making discrete switched shunt reactive support not practical because power angles become excessive, and local voltage collapse with loss of load can occur. Figure 7 below shows the simulated dynamic voltage response of The Wink – Culberson – Yucca Drive Loop for one such scenario.

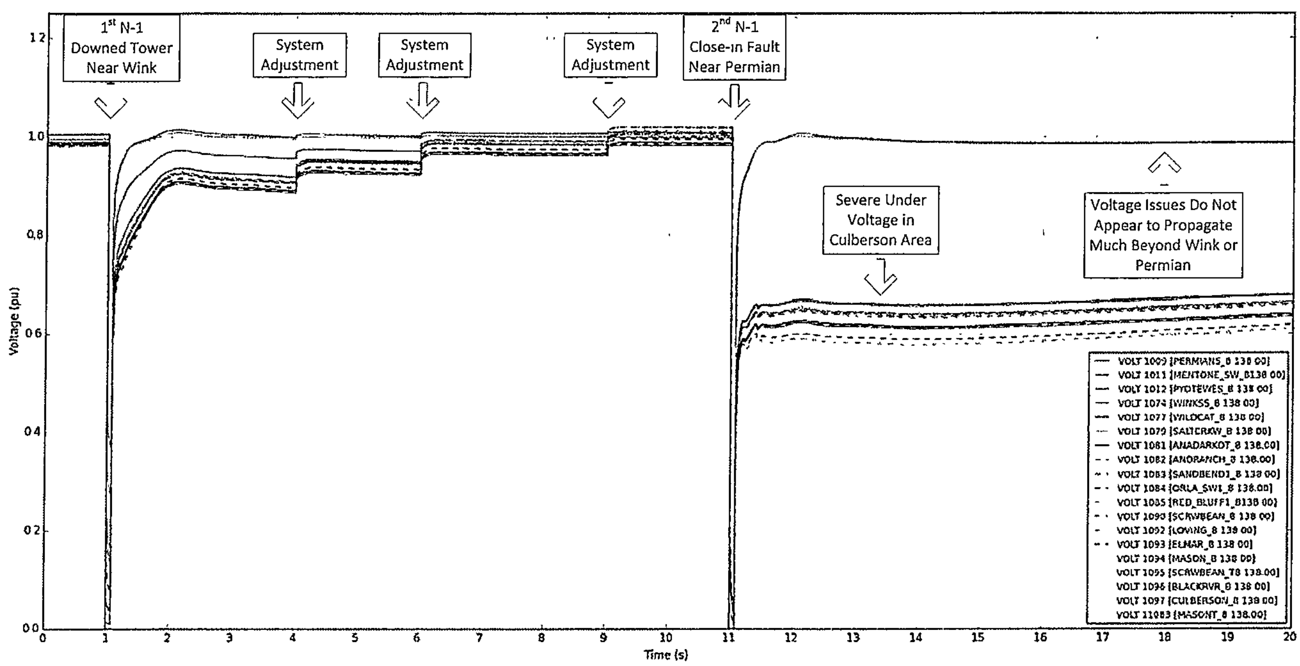


Figure 7 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Light Motor Load)

It should be noted that while this simulation is above normal minimum study requirements, it is in line with clearance requests and has significant consequences including load loss exceeding 300 MW. Additionally, the simulation plot above was performed assuming light motor load. If heavy motor load is assumed the dynamic stability simulation fails to converge after the second fault. In fact for The Wink – Culberson – Yucca Drive Loop, heavy motor load may be a more reasonable assumption given the amount of oil and natural gas related customers served from this line. In that scenario, after the system is adjusted, the next contingency results in a local voltage collapse and loss of load that cannot be mitigated by normal operator action. The voltages at Permian Basin and Wink however do stabilize, showing the condition does not propagate to the rest of the system.

The FWTP will strengthen system voltage and provide a strong 345 kV source into The Wink – Culberson – Yucca Drive Loop. This will address the voltage collapse concerns described previously and provide a resilient long-term solution for increasing system strength in the area. Figure 8 and Figure 9 below show the same dynamic simulation with the FWTP modeled. Figure 8 shows the voltage response assuming light motor loading and Figure 9 shows the voltage response assuming heaving motor load. In both cases, the voltage collapse conditions after the worst N-1-1 contingencies are completely mitigated by the 345 kV loop.

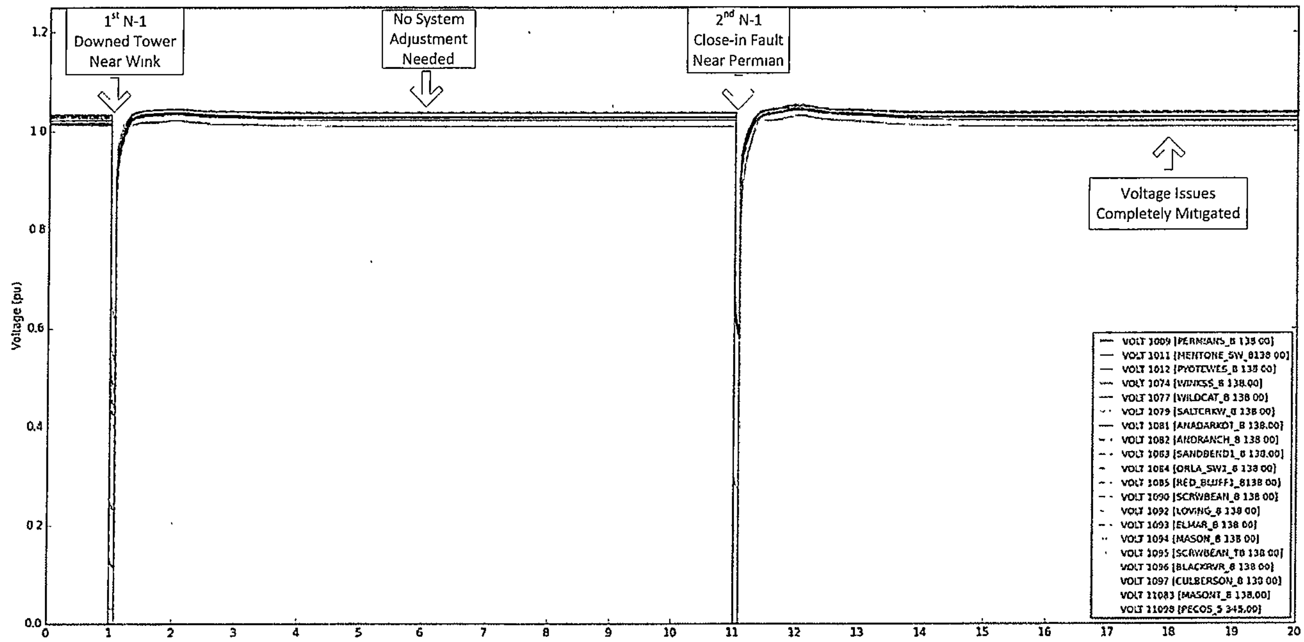


Figure 8 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Light Motor Load) – FWTP

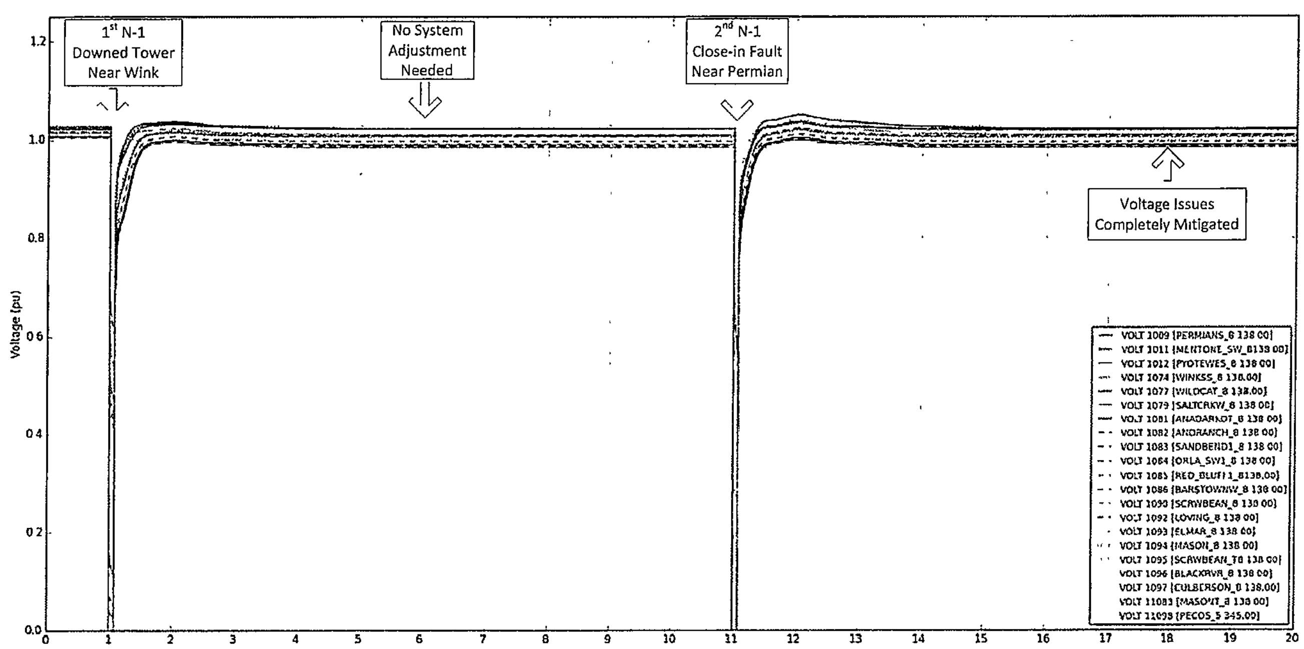


Figure 9 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Heavy Motor Load) – FWTP

ERCOT Studies

ERCOT identified similar planning criteria violations to the Oncor studies in its 2015 Regional Transmission Plan (RTP) and its preliminary 2015 West Texas Study (WTS) results.

The 2015 ERCOT RTP shows similar results to the Oncor studies in the Culberson loop area, with the RTP cases becoming unsolvable under the P1 contingency loss of any one of several single segment circuits on The Wink – Culberson – Yucca Drive Loop. Using the 2015 ERCOT RTP 2018 Summer case posted by ERCOT on April 14, 2015, the same unsolved case conditions can be seen after loss of the Wink – Wildcat 138 kV line section. Using either the 2015 ERCOT RTP 2020 or the 2021 cases, the same unsolved case conditions result after the loss of either the Loving – Anderson Ranch or the Wink – Wildcat 138 kV line sections.

As a result, the need for this project was identified in the 2015 RTP as reliability project 2015 RTP-FW3. A portion of the FWTP for a new 345 kV line to the area from Odessa EHV and Moss was identified as a potential project solution. Currently ERCOT is working on the 2016 RTP and has indicated to Oncor that the preliminary results are showing similar issues in the area.

Similarly, the same conditions were seen in the preliminary results provided to Oncor for the 2015 ERCOT WTS. Using the 2015 ERCOT WTS 2017 Summer Case posted by ERCOT on May 15, 2015, loss of the Wink – Loving 138 kV line section results in The Wink – Culberson – Yucca Drive Loop unable to maintain adequate voltage limits and results in the same unsolved case conditions seen by Oncor studies. The ERCOT WTS 2019 and 2020 cases show similar results under the same contingencies.

AEP Studies

As part of the Barrilla Junction Area Improvement Project RPG submission, AEP performed numerous steady-state studies assessing the integrity of the transmission system in The Barrilla Junction Area. In these studies, AEP identified additional thermal and voltage violations beyond the direct interconnection facilities of the Barrilla Junction to Yucca Drive 138 kV Line that exceed thermal ratings. These include the 138 kV and 69 kV transmission lines heading south from Barrilla Junction towards the Marfa and Ft. Davis Area, as well as the 138 kV and 69 kV transmission lines heading east from Barrilla Junction/Solstice towards Ft. Stockton Plant and Rio Pecos.

In order to determine the most appropriate system conditions to model for evaluating the reliability of the study area, several scenarios were considered. Combinations of wind, gas and solar generation dispatch were adjusted, simulated, and results compared. Each of the adjusted system conditions used to determine the final scenarios analyzed for the study are detailed in the sections below.

AEP utilized the summer peak power flow cases with High Solar/Low Wind/High Gas (HS/LW/HG), High Solar/High Wind/Low Gas (HS/HW/LG), Low Solar/Low Wind/Low Gas (LS/LW/LG) and Low Solar/Low Wind/High Gas (LS/LW/HG) dispatches.

- In the Low Wind (LW) dispatch, all the area wind generators were dispatched at 20% with the exception of the two Woodward units that were dispatched to 0%.
- In the High Wind (HW) dispatch, all area wind generators including the Woodward units were dispatched at 100% of Pmax.
- In the Low Solar (LS) dispatch, all the solar generators in the study area were dispatched to 0%.
- In the High Solar (HS) dispatch, all solar generators in the study area were dispatched at 100% of Pmax.

- In the Low Gas (LG) dispatch, all the area gas generators were dispatched at 20% with the exception of the Permian Basin gas units that were dispatched at 0%.
- In the High Gas (HG) dispatch, all the area gas generators were dispatched at 100% of Pmax.

The dispatch assumptions associated with the HS/LW/HG, HS/HW/LG, LS/LW/LG and LS/LW/HG scenarios are shown below in Table 3.

	2020 HS/LW/HG	2020 HS/HW/LG	2020 LS/LW/LG	2020 LS/LW/HG
Solar	100%	100%	0%	0%
Wind	20%	100%	20%	20%
Woodward	20%	100%	0%	0%
Gas	100%	20%	100%	100%
Permian	100%	20%	0%	100%

Table 3 – AEP Barrilla Junction Area Study Dispatch Assumptions

As mentioned in the Barrilla Junction Area Improvement Project RPG submittal, AEP studies revealed a number of remaining thermal issues on the two 138 kV transmission paths out of Rio Pecos after the Barrilla Junction Area Improvement Project is implemented. The resulting line loading in The Barrilla Junction Area is shown below in Table 4.

Branch	Rate C (MVA)	Study Case LW/LS/LG %Loading	Study Case HW/HS/LG %Loading	Study Case LW/HS/HG %Loading
Rio Pecos – Woodward Tap 138 kV	170	124	20	18
Rio Pecos – TNMP Woodward Tap 138kV	154	131	113	70
Ft. Stockton Plant 138/69 kV auto transformer	68.8	116	123	67
Ft. Stockton – Tombstone 138 kV	170	99	38	23
Ft. Stockton Plant – TNMP Airport 138 kV	158	106	38	21
Ft. Stockton Plant – Barrilla Jct/Solstice 138 kV	170	124	106	65
Woodward Tap – Tombstone 138 kV	170	124	48	28
Ft. Stockton – Barrilla Junction 69 kV	38	116	127	58
TNMP 16th Street – TNMP Woodward Tap 138 kV	154	131	59	18
TNMP 16th Street – TNMP Airport 138 kV	158	113	44	14

Table 4 – AEP Barrilla Junction Area Study Line Loading

AEP studies show certain scenarios where the amount of generation able to be exported from the Barrilla Junction Area would be limited because of thermal constraints on the transmission system. With the large amount of generation coming online and significant constraints due to the limited exit paths out of the Barrilla Junction Area, generators in the area would likely see curtailments until additional transmission improvements were made in the region.

Additionally, further stability studies have identified voltage stability concerns in the McCamey 138 kV transmission system as a result of the additional generation interconnections at or near the Bakersfield Sw. Sta. The studies identified certain scenarios where a N-1-1 contingency would limit the amount of generation that can be exported due to voltage stability concerns.

The FWTP will provide an additional export path for generation that would otherwise flow into the McCamey 138 kV system, addressing export limitations due to potential voltage instability. Additionally, the project would create a looped exit path for the approximately 2.2 GW of potential new generation coming online in the Far West Texas transmission system.

Short Circuit Strength

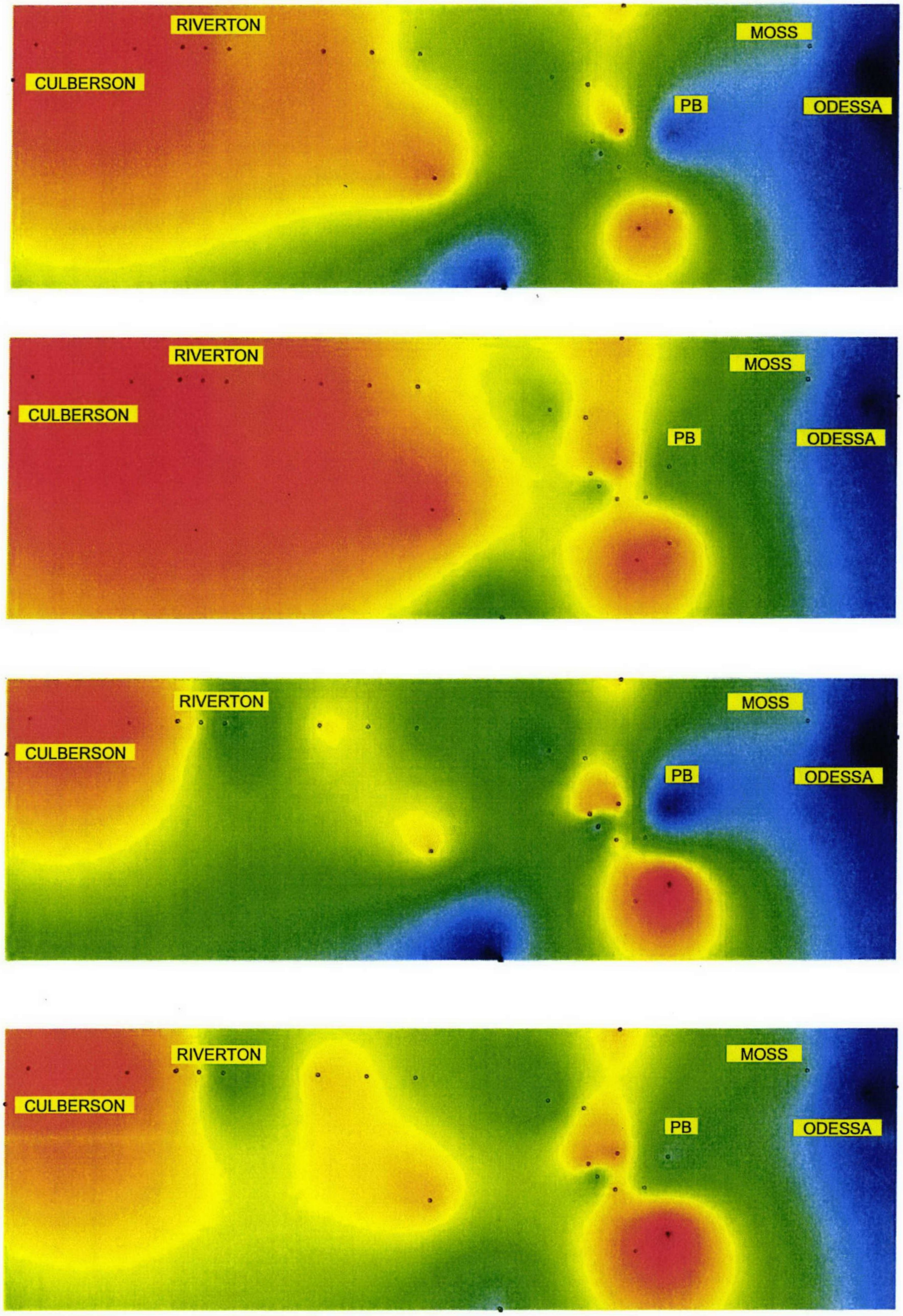
Short circuit strength in the FWTP's area is also a concern. In the FWTP's area, there are several long lines with significant load that could become radial under P1 contingencies. If a radial line is both long and heavily loaded, it can become difficult for relays to distinguish between fault and load current. Furthermore, low short circuit strength can cause issues for customers, such as inability to start large motors.

Low short circuit strength in an area can cause difficulty in properly protecting the transmission system. Transmission line relays must protect for faults anywhere along the line, even during clearance/outage scenarios. If fault currents in an area are generally low, the outage of a nearby source can significantly reduce the availability of relay settings that reliably trip for any fault condition, while simultaneously avoiding trips for any non-fault condition. Additionally, relay coordination with breakers in surrounding areas may become problematic.

For example, during certain outages in The Wink – Culberson – Yucca Drive Loop, a fault at the remote end of the radial section may result in fault currents as low as 860 Amperes, which is equivalent to 205 MVA of load at nominal voltage. Under these conditions, the maximum load that could be reliably served on this circuit must be below 205 MVA since some margin is required to provide secure protection. This amount is not near the capacity of the line (2,569 Amperes or 614 MVA) and does not meet criteria for system protection requirements. With the FWTP in place, simulations indicate that fault current may increase to 3,300 Amperes for the same scenarios, which is equivalent to 788 MVA of load, exceeding the conductor rating and providing sufficient margin for secure protection.

Figure 10 (next page) shows a color contour map representing the relative short circuit strength in the north part of FWTP's area. The regions colored in red, such as The Wink – Culberson – Yucca Drive Loop in the upper left corner of the diagram, indicate areas with very low short circuit strength. Much of the area is relatively weak, particularly when compared to areas closer to Odessa EHV and conventional generation, shown in the regions in blue. The simulations represented in the maps show the scenario with conventional generation in the FWTP's Area in-service. The situation becomes more dismal if generation in the area is out-of-service as indicated.

The addition of a strong source, such as the injection of a new 345 kV source, into the FWTP's area aids in increasing short circuit strength and stability, particularly when nearby conventional generation is not in-service.



Normal Conditions

PB In-service

Normal Conditions

PB Out-of-service

Normal Conditions

PB In-service

FWTP In-service

Normal Conditions

PB Out-of-service

FWTP In-service

Figure 10 – Relative Short Circuit Strength Color Contour Maps – FWTP

High Voltage Points-of-Delivery (PODs)

AEP and Oncor continue to receive multiple inquiries from oil and natural gas producers for future high voltage (HV) interconnections along the transmission lines in the Delaware Basin area. In The Wink – Culberson – Yucca Drive Loop, customers with existing HV points-of-delivery (PODs) in the area have projected increases in load. Not included in the projections shown previously in Table 1 are four requests for new customer-owned substations totaling 45 MW. One potential customer has indicated future development plans in the Delaware Basin near the FWTP area that includes electrical requirements that could reach as high as 180 MW total.

The FWTP will help to serve additional load growth by providing extra high-voltage transmission service closer to existing and future customers in the Delaware Basin, where HV PODs can be established. Extending the 345 kV system into these regions of the Delaware Basin will increase system strength and provide voltage support in an area where customers frequently experience low voltage problems and strict motor start limitations.

TSP Point-of-Interconnections

Challenges in West Texas with regards to rapid changes in generation interconnections, customer service requests, system protection, engineering, constructability, operability, outage/clearances and maintainability have encouraged West Texas TSPs to expand on joint coordination efforts for planning future area needs. As the area continues to see generation and load additions, joint coordination will be needed to ensure a strong and reliable transmission system.

AEP and Oncor have performed joint planning to determine optimal solutions that would benefit all parties. As mentioned previously, AEP and Oncor have immediate needs to rebuild the Yucca Drive – Barrilla Junction 138 kV Line via the Barrilla Junction Area Improvement Project, however these 138 kV upgrades do not resolve all thermal issues on the existing 138 kV lines between Barrilla Junction/Solstice and Rio Pecos. Additionally, Oncor has needs to address the reliability issues in The Wink – Culberson – Yucca Drive Loop.

Texas New Mexico Power (TNMP) has also engaged AEP and Oncor in joint planning discussions in Ward, Winkler, and Reeves counties. TNMP has indicated expected load increases on their transmission system due to large HV customers and sees the need for additional upgrades due to potential thermal and voltage issues post-contingency. TNMP's system in this area is comprised solely of a 69 kV network with radial circuits branching off at multiple points and relies on transmission sources from Oncor's Wink and Permian Basin stations. TNMP has indicated desires for future HV points-of-interconnection with AEP and Oncor in the area, and would greatly benefit from the strong injection source that 345 kV provides.

The FWTP will address planning criteria violations and operational issues for AEP, Oncor and TNMP. Additionally a looped 345 kV line in the area will create additional transmission infrastructure for future points-of-interconnection between other TSPs. Implementation of a 345 kV source provides for a resilient system that all TSPs in the area can benefit from and provides for the beginning of a 345 kV loop around the area, that can be expanded to provide additional lines to the north or east as future needs dictate.

Operational Flexibility

The lack of operational flexibility when transmission facilities are taken out of service during construction and maintenance is an increasing problem in West Texas. Due to increasing load levels and uncertain availability of wind and other generation in the area, the ability to take facilities out of service for scheduled clearances, maintenance, or testing is limited by voltage and thermal constraints caused by the next contingency. This often leads to congestion and/or unavailability of clearances.

Numerous elements in the FWTP's area are noted as High Impact Transmission Elements (HITEs) by the ERCOT Outage Coordination Improvements Task Force (OCITF). These are transmission elements where outages have contributed to significant congestion and transmission constraints in recent history. Notable elements include the Moss Switch 138 kV Bus, Odessa EHV 138 kV Bus, Midland East – Odessa EHV 345 kV Line, Midland East – Moss 345 kV Line, Moss – Odessa EHV 345 kV Line, and the Odessa EHV 345/138 kV autotransformer #3. With many constraining 345 kV elements in the local area, expansion of the 345 kV system will help strengthen the area to enable clearances and withstand unplanned outages with fewer congestion concerns.

The FWTP will help strengthen the system voltage and increase the operational flexibility in West Texas, allowing utilities to upgrade facilities, perform scheduled maintenance and perform testing of their facilities.

Region Long Term Upgrade Path

In addition to providing the best technical solution to support planning standard requirements and maintain a reliable system today, the need to optimize improvements to adequately meet future needs must be considered. With limited amounts of transmission infrastructure in areas of far West Texas, new project options to address reliability issues in a fast changing landscape can be limited.

AEP's and Oncor's long range planning analysis considered needs in The Wink – Culberson – Yucca Drive Loop, The Barrilla Junction Area, and Far West Texas in general for future voltage support, transfer capacity, and load serving transformers. Future long-term projects that have been identified include:

- Add 345/138 kV, 600 MVA autotransformer at Sand Lake Sw. Sta.
- Add 345/138 kV, 600 MVA autotransformer at Wolf Sw. Sta.
- Add 345/138 KV, 600 MVA autotransformer at Fort Stockton Plant Sw. Sta.
- Add second 345/138 kV, 600 MVA autotransformer at Moss Sw. Sta.

The Far West Texas Project will have built-in upgrade paths to accommodate future growth needs in the region. This will provide flexibility for future project additions depending on timing of future load or generation increases. Based on increasing load and future interconnections with other TSP's in The Wink – Culberson – Yucca Drive Loop, the Sand Lake 345/138 kV autotransformer can be quickly installed to meet required needs.

In addition to locations where an autotransformer can be installed relatively quickly, a second 345 kV circuit can be installed to provide additional transfer capacity in The Wink – Culberson – Yucca Drive Loop and The Barrilla Junction Area. These upgrades will ensure the proposed solution is a resilient option that can meet future long range needs in Far West Texas.

Project Description

AEP and Oncor will coordinate respective portions of the project to support design, construction, and other activities. The estimated in-service date is 2021 to 2022. This date may change based on uncertainty in the timing of certification, environmental assessment, land acquisition, critical project status and/or other requirements. Below are individual descriptions of the pieces of this project:

Odessa EHV – Riverton 345 kV Line (Oncor)

Add a second circuit to the existing 16-mile Moss Sw. Sta. – Odessa EHV 345 kV double-circuit structures. Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Sw. Sta. Install 345 kV circuit breaker(s) at Odessa EHV. Connect the new circuit from Riverton Sw. Sta. and terminate at Odessa EHV to create the new Odessa EHV – Moss – Wolf – Riverton 345 kV Line.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new rights-of-way (ROW). The new line should be routed near the future Wolf Sw. Sta. near Permian Basin SES to provide for future facility additions. Oncor is requesting "critical" designation for this line to quickly mitigate the voltage collapse and load loss issue described previously.

Riverton Switching Station (Oncor)

Expand the Riverton Sw. Sta. to install a 345 kV ring-bus arrangement with one 600 MVA, 345/138 kV autotransformer. Install two 37.5 Mvar (75 Mvar total) shunt reactors on the tertiary of the autotransformer.

Solstice 345 kV Switching Station (AEP)

Expand the Solstice Sw. Sta. to install a 345 kV ring-bus arrangement with one 675 MVA, 345/138 kV autotransformer.

Riverton – Solstice 345 kV Line (AEP & Oncor)

Construct a new approximately 66-mile 345 kV line on double-circuit structures with one circuit in place from Riverton Sw. Sta to Solstice Sw. Sta. Oncor will build half the line from Sand Lake and AEP will build half the line from Solstice.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new ROW. The new line should be routed near the future Sand Lake Sw. Sta. for future facilities additions.

Lynx 345 kV Switching Station (AEP)

Expand the Lynx Sw. Sta. to install a 345 kV ring-bus arrangement with one 675 MVA, 345/138 kV autotransformer.

Solstice – Lynx 345 kV Line (AEP)

Construct a new approximately 59-mile 345 kV line from Solstice Sw. Sta. to Lynx Sw. Sta. on double-circuit structures with one circuit in place. The new line should be routed near Fort Stockton Plant for future facilities additions.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new ROW.

Lynx – Bakersfield 345 kV Line (AEP)

Construct a new approximately 9-mile 345 kV line from Bakersfield station to the Lynx Sw. Sta. on double-circuit structures with one circuit in place.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new ROW.

Project Costs

The total cost of these improvements is estimated at $423 million. The approximate station and line works costs for AEP and Oncor are shown below.

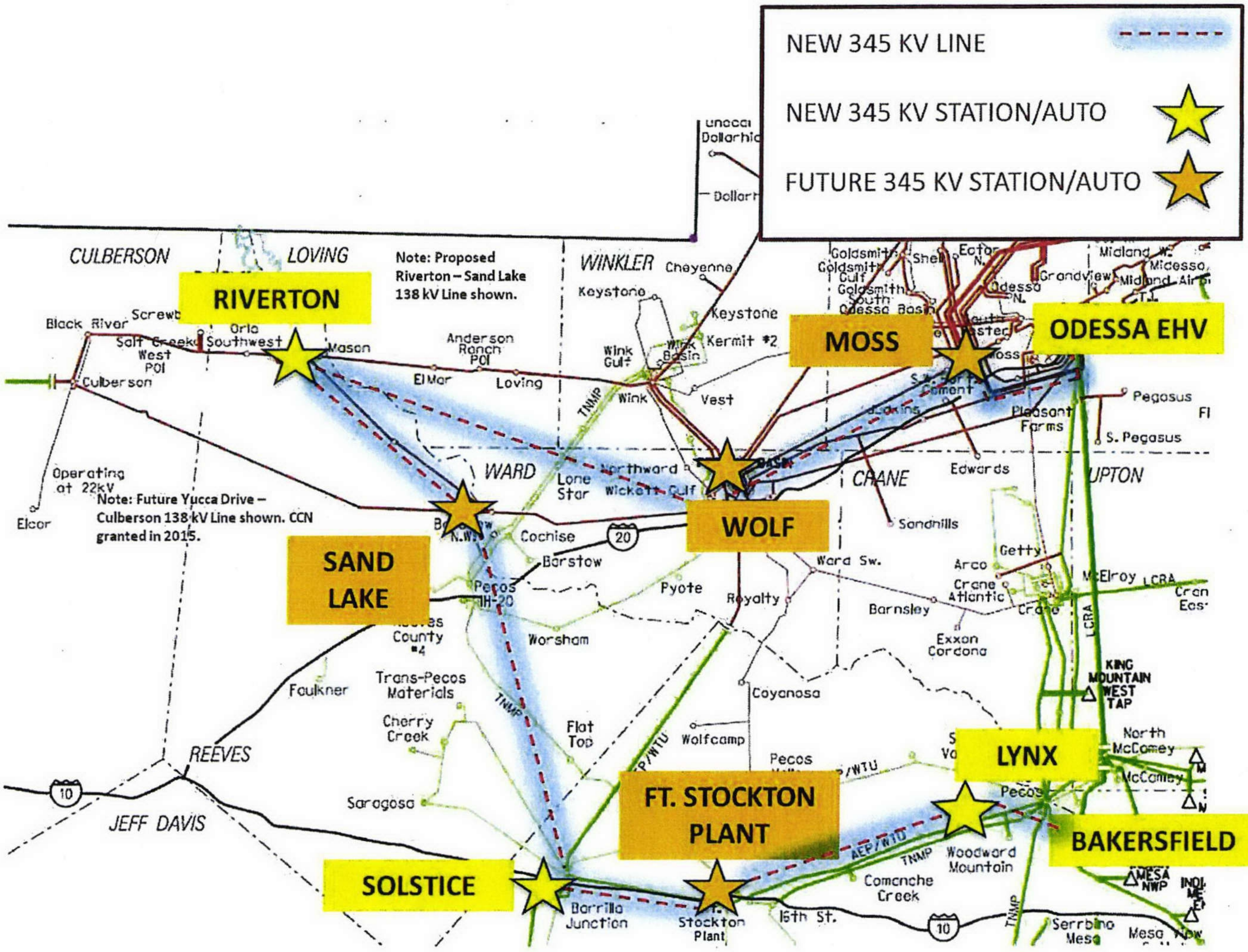
AEP

- Station: $43 million
- Line: $146 million

Oncor

- Station: $17 million
- Line: $217 million

Figure 11 below shows a depiction of the Far West Texas Project overlay using blue highlighting.



One-line Diagram

Figure 12 below shows a one-line diagram of the area, where the Far West Texas Project components are dashed.

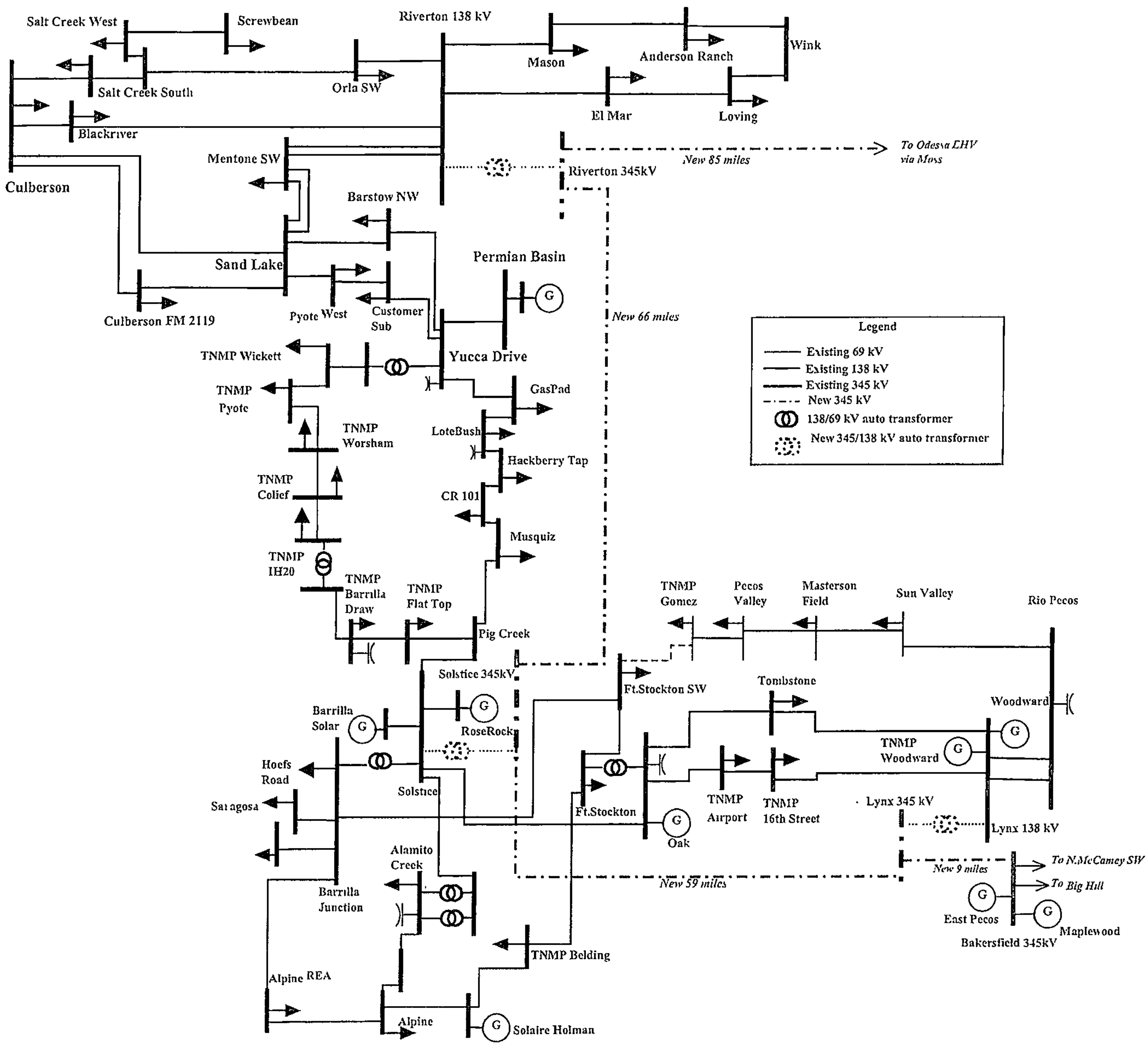


Figure 12- Far West Texas Project One-Line Diagram

Alternative Projects

Both AEP and Oncor considered various options to resolve the identified reliability issues and provide adequate transmission infrastructure to connect new solar generation and oil and natural gas load. Alternatives to the Far West Texas Project are various combinations of existing 69 kV rebuilds, 138 kV rebuilds, and numerous large dynamic reactive devices. While these alternative projects would address local thermal or voltage issues with varying levels of performance depending on local area generation dispatch and load projections, they have limited improvement on a the larger scale for providing a strong transmission source and a resilient solution to increasing system strength in the area.

Providing single radial 345 kV injection points in the Far West Texas Project's area was considered and would greatly improve system strength, reliability, and address planning criteria violations. However the first contingency loss of any new radial 345 kV line or single 345/138 kV autotransformer would negate the benefit of the single 345 kV source. For example, under certain N-1-1 events, whether through planned or unplanned outages, the same planning criteria issues and subsequent voltage collapse risks in The Wink – Culberson – Yucca Drive Loop would remain. As load increases in the region the ability to take these facilities out for maintenance, testing, or construction clearances will become increasingly difficult. The most effective solution is a 345 kV loop around the area that can be established to provide bi-directional capability of the new 345 kV source.

Alternative - Dynamic Reactive Device(s), 138 kV, and 69 kV Upgrades

In order to adequately address the short-term criteria violations found by AEP and Oncor, a combination of many 138 kV and 69 kV rebuilds in addition to new dynamic reactive devices, will be needed. These projects are estimated to cost $480 million and higher.

With no 345 kV source into The Wink – Culberson – Yucca Drive Loop area of the Delaware Basin, Oncor studies indicate that 138 kV network expansion, in combination with large dynamic reactive devices, will be required to support future load growth by helping to provide voltage regulation and enabling adequate power transfer under reasonable operating scenarios.

Oncor dynamic studies have determined that a large synchronous condenser (300 Mvar minimum) would be needed in order to address the previously described issues in The Wink – Culberson – Yucca Drive Loop. The studies show that a Static VAR Compensator (SVC) or a Static Synchronous Compensator (STATCOM) would not converge for a number of simulations, indicating an insufficiency for mitigating the voltage collapse risks.

Figure 13 below shows a comparison of the voltage responses after the worst N-1-1 contingency in The Wink – Culberson – Yucca Drive Loop with a 300 Mvar synchronous condenser modeled at Riverton Sw. Sta. In the simulation, heavy motor load was assumed.

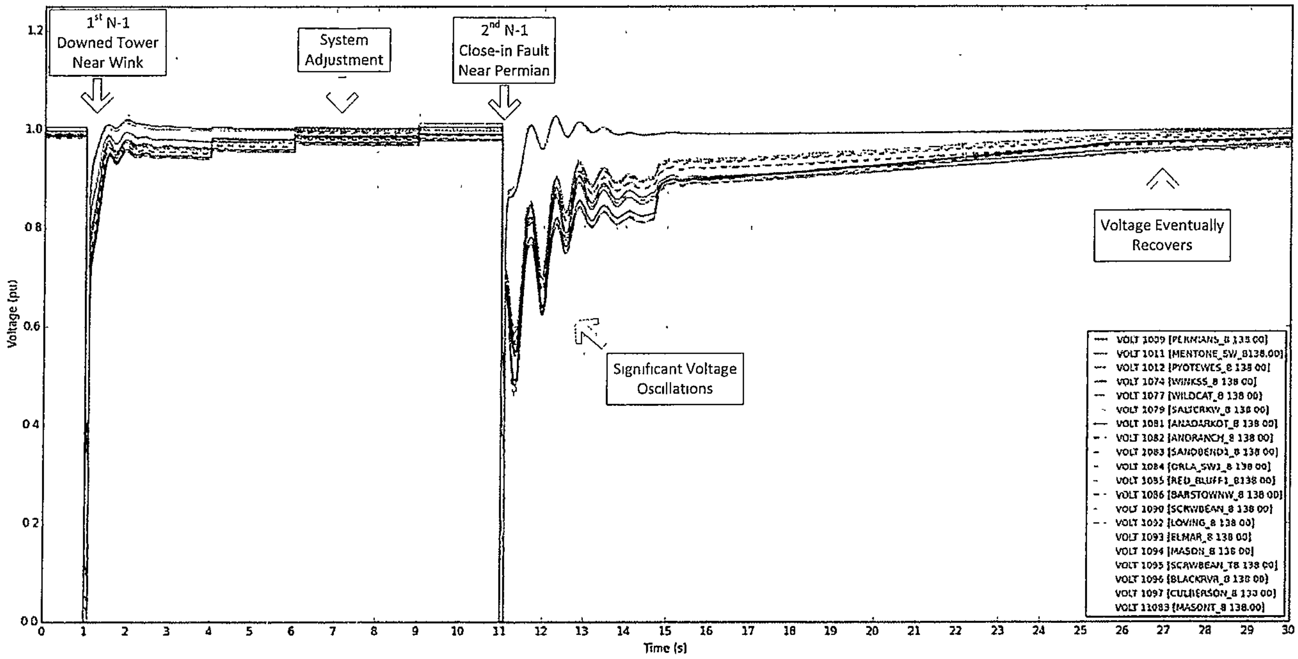


Figure 13 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Heavy Motor Load) – 300 Mvar Synchronous Condenser

It should be noted that while the voltage in The Wink – Culberson – Yucca Drive Loop eventually recovers to normal operating levels, there are significant voltage oscillations upon recovery. With potential swings of more than 0.2 PU, electrical equipment including those of customers mentioned previously in this report could be at risk. The required device would likely need to be larger, such as 400 Mvar. Figure 14 below shows the same simulation with a 400 Mvar synchronous condenser modeled.

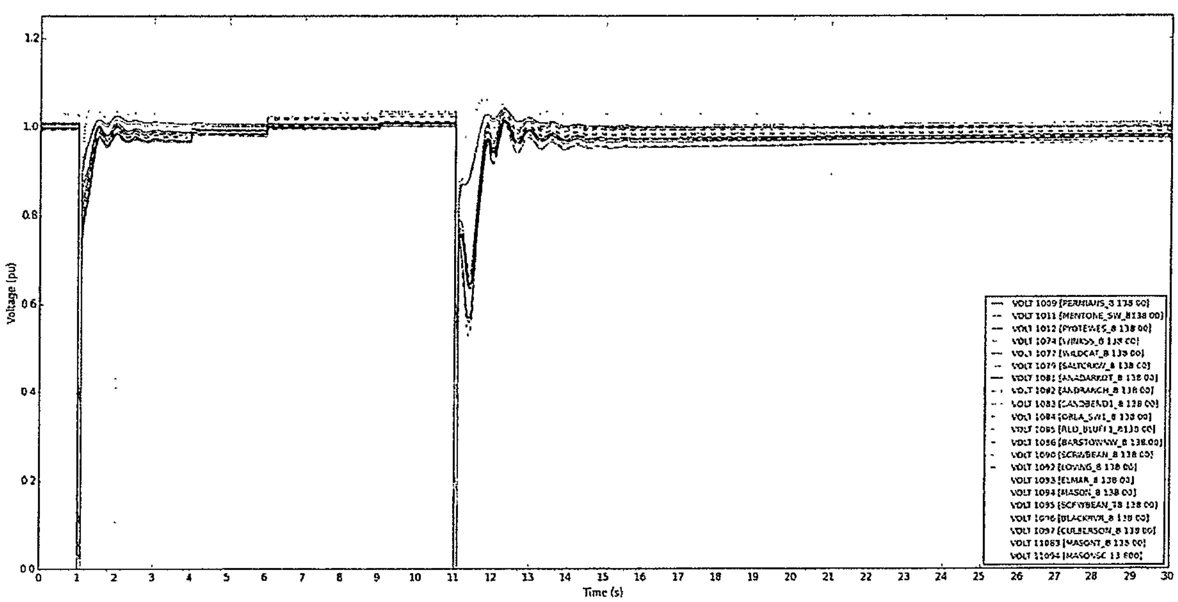


Figure 14– Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Heavy Motor Load) – 400 Mvar Synchronous Condenser

Placing such a large, complex device in an extremely remote area also has significant operational and maintenance concerns. The area near Riverton Sw. Sta. is extremely remote, and with limited road access and no nearby population, such a facility would be away from field personnel responding to any planned or unplanned outage, maintenance, or testing. Re-occurring inspections and maintenance will be required which must also be considered in the evaluation of installing such a device. The on-going service costs are not included in the alternative estimate. Additionally, the large size required for a 400 Mvar device will be cumbersome through construction, maintenance, and testing. Two synchronous condensers would be required for redundancy under contingency loss of the first device.

While this alternative addresses the initial planning criteria concerns, this option does not increase system strength and does not provide any strong injection points to the 138 kV system. Additionally, there is no clear upgrade path with these 138 kV and 69 kV alternatives. Future 138 kV projects including new circuits and additional dynamic reactive devices will likely be required as load increases on The Wink – Culberson – Yucca Drive Loop, adding to the future costs of the alternative.

Oncor studies show that if load growth goes beyond current projections in the area, the synchronous condenser would experience angular instability and the simulation solutions would diverge. Figure 15 below shows the voltage response under the worst N-1-1 contingency, if load growth on The Wink – Culberson – Yucca Drive Loop increased above current projections.

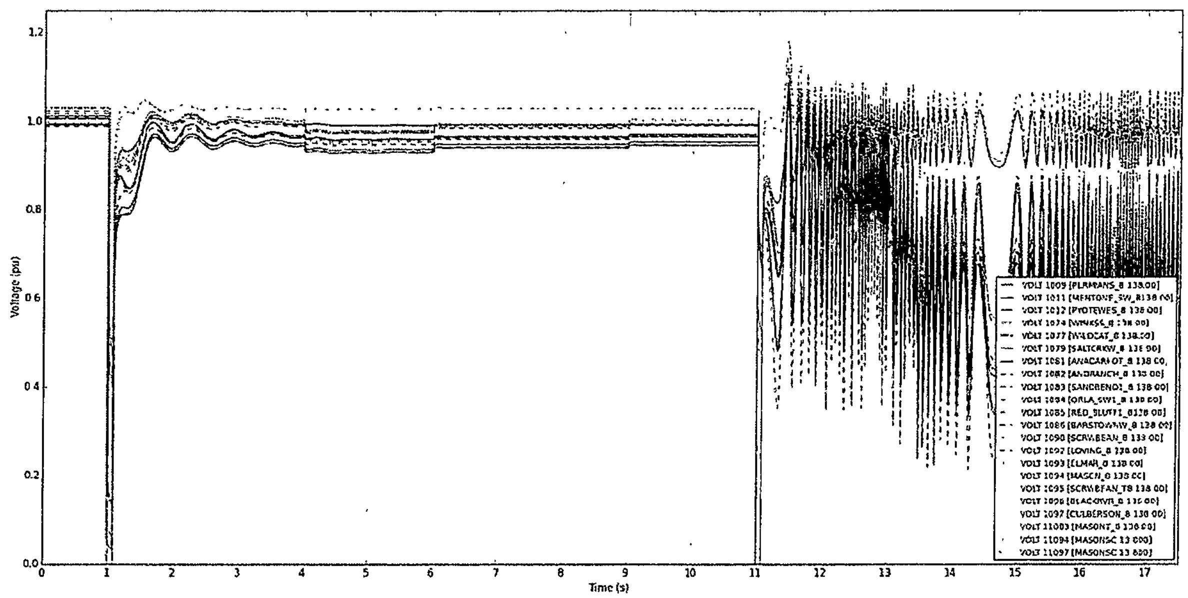


Figure 15 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency – Synchronous Condenser

With the FWTP in place, The Wink – Culberson – Yucca Drive Loop could still withstand an increase above current load projections. Figure 16 below shows the FWTP under these conditions with the same N-1-1 contingency. This means that the FWTP will not only resolve the current issues of voltage collapse and load loss, but will also provide ample transmission capacity for load growth well into the future.

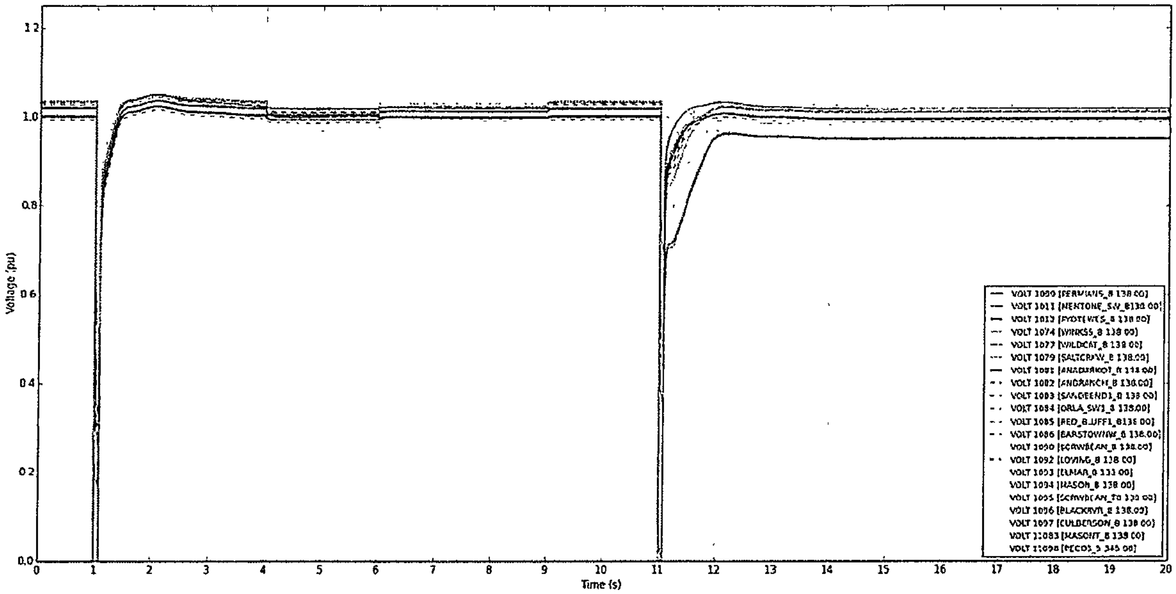


Figure 16 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency – Far West Texas Project

With no 345 kV source into The Barrilla Junction Area, AEP studies show that the remaining 69 kV and 138 kV lines in the Barrilla Junction Area that have not been addressed by the Barrilla Junction Area Improvement Project would need to be rebuilt. This equates to more than 170 miles of existing 69 kV and 138 kV transmission lines.

While rebuilding the existing corridor of transmission lines in The Barrilla Junction Area would address the thermal overloading concerns, this alternative does not provide a new transmission path into The Barrilla Junction Area for any new solar generation in the region to interconnect. Additional new source paths may be needed in the area to accommodate growth beyond what has been studied. AEP studies have also shown the 345 kV option to perform better under the same contingency and dispatch scenarios as this alternative and provides for additional transfers on the existing Ft. Stockton Plant – Rio Pecos paths.

Conclusion

The joint decision by AEP and Oncor to construct the Far West Texas Project will provide a backbone 345 kV infrastructure to support load growth, support voltage, improve system protection issues and provide pathways for new generation interconnects in the region southwest of Odessa. The Far West Texas Project will help support transmission voltage in the Delaware Basin area both pre- and post-contingency by providing a strong source into an area that is primarily served by 138 kV and 69 kV transmission lines, and addresses reliability issues for AEP, Oncor and other TSPs.

Additionally, the Far West Texas Project would also allow flexibility for future 345 and 138 kV lines, future autotransformers, and additional connections between TSPs as needs dictate. It is the best overall solution to create a resilient transmission system in Far West Texas, an area that is expected to have substantial future load growth and generation penetration.

Far West Texas Project 2

ERCOT REGIONAL PLANNING GROUP SUBMITTAL

Feb 01, 2018

ASSETS PLANNING
DISTRIBUTION AND TRANSMISSION
BUSINESS AND OPERATIONS SERVICES

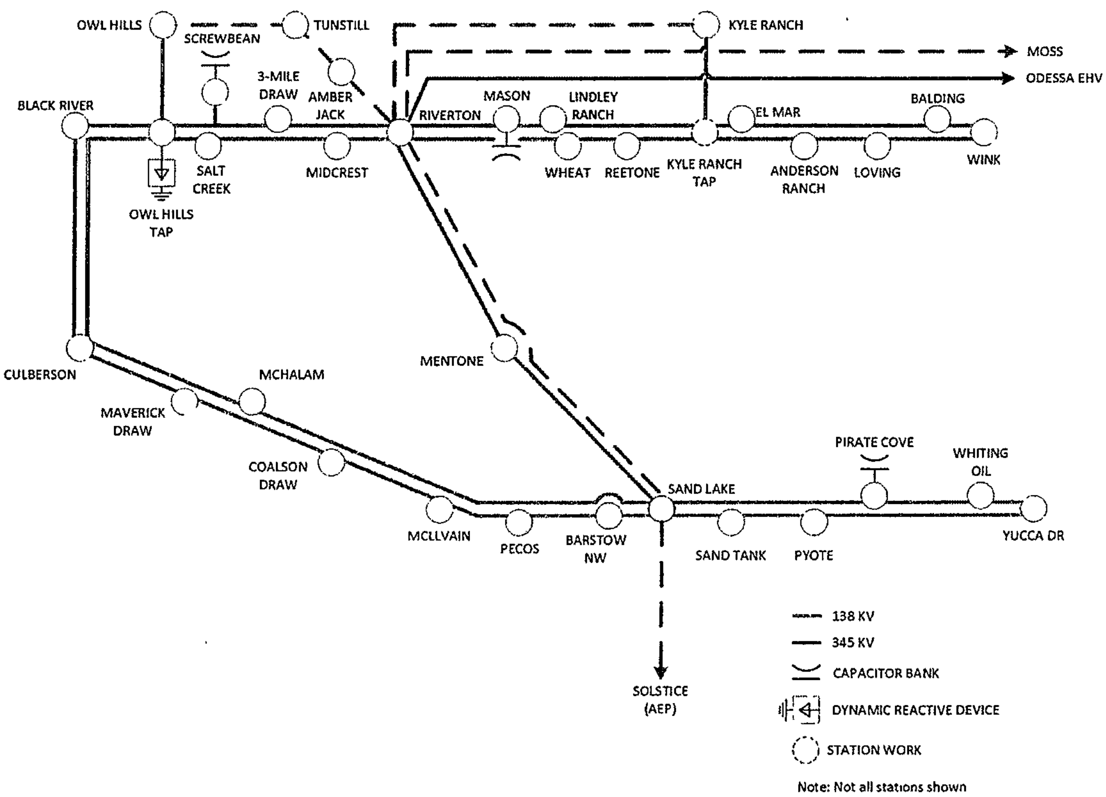
ONCOR®

Table of Contents

Executive Summary

Oncor proposes to construct the Far West Texas Project 2, a Far West Zone transmission project consisting of the following elements:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with one circuit in place from Sand Lake Sw. Sta. to Solstice Sw. Sta. Oncor will build half the line from Sand Lake and AEP will build half the line from Solstice.
- Sand Lake 345 kV Sw. Sta. additions including two 600 MVA, 345/138 kV autotransformers.
- Install the second circuit on the Riverton –Sand Lake 345 kV Line structures. Connect the new circuit from Riverton 345 kV Sw. Sta.to Sand Lake 345 kV Sw. Sta. to create the new Riverton – Sand Lake 345 kV Line.
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV Line structures (Moss – Riverton 345 kV Line)
- Construct the new Kyle Ranch Tap 138 kV Sw. Sta. in the Wink – Riverton double-circuit 138 kV Line
- Construct a new approximately 20-mile 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Substation to Riverton 138 kV Sw. Sta.
- Construct a new approximately 20-mile 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Substation to Riverton 138 kV Sw. Sta.



This $194 million Tier-1 project in Reeves, Loving, and Pecos counties is recommended for construction to meet a Summer 2023 in-service date. This projected date may change based on requirements surrounding timing for environmental assessment, certification/licensing request and regulatory approval, land/rights-of-way acquisition, or other project related requirements. The need date may also be sooner based on the timing of new load additions in the area.

In June 2017, the ERCOT Board of Directors approved a portion of the Far West Texas Project, which included construction of two new 345 kV lines and autotransformer additions. In ERCOT's independent review of the project, ERCOT indicated that the approved project could serve up to 717 MW along the Oncor Wink – Culberson Yucca Drive – Culberson 138 kV transmission lines (The Culberson Loop) before other transmission system improvements would be required. ERCOT also identified future augmentations to the approved project that could serve up to 1037 MW.

Oncor has contractually confirmed load additions of 1013 MW that surpass ERCOT's indicated 717 MW limit for the approved Far West Texas Project. Additionally, known potential load additions may bring the total to 1339 MW. With these additions of load, expansion of the approved Far West Texas Project is needed to address reliability requirements and ensure the transmission system in the area is able to meet this load demand.

The Far West Texas Project 2 will complete the 345 kV loop between Riverton and Solstice, providing additional injection points into Oncor's Wink – Culberson - Yucca Drive 138 kV transmission lines (The Culberson Loop). The project will also add new network connections that will increase reliability, provide additional load serving capacity, support voltage conditions, enable clearances, and increase operational flexibility.

Introduction

This report describes the need to construct the Far West Texas Project 2 in Loving, Reeves, and Pecos counties.

In June 2017, the Electric Reliability Council of Texas (ERCOT) Board of Directors approved a portion of the Far West Texas Project, a Tier 1 transmission project to address several unacceptable voltage and transmission facility loading conditions on Oncor and American Electric Power (AEP) facilities in the far west region. ERCOT's analysis of the project reviewed immediate system needs based on existing loads and loads with signed Facility Extension Agreements (FEAs). As such the approved project elements were a subset of the proposed Far West Texas Project and included the new radial Odessa EHV – Riverton 345 kV Line, the new radial Bakersfield – Solstice 345 kV Line, two 345/138 kV autotransformers at Riverton, and two 345/138 kV autotransformers at Solstice.

In the independent review for the Far West Texas Project, ERCOT performed voltage stability analysis which indicated that the maximum load serving capability for the approved project was 717 MW along Oncor's Wink – Culberson 138 kV Line and the Yucca Drive – Culberson 138 kV Line, referred to as The Culberson Loop. ERCOT also indicated future expansion options for the Far West Texas Project to increase the load serving capacity up to 1037 MW. Expansion options included the need to connect the two radial 345 kV lines and install a Synchronous Condenser.

Oncor has continued to see large load growth along these transmission lines due to expansion of the oil and natural gas industry and recently submitted the Far West Texas Dynamic Reactive Devices (DRD) Project in December 2017 to address near term load increases in the 2019 timeframe. Additional large requests for electric service along these lines have been received, which will require expansion of the Far West Texas Project elements approved in 2017, including connection of the radial Odessa EVH – Riverton and Bakersfield – Solstice 345 kV Lines.

Purpose and Necessity

Load Growth

Oncor has continued to see load growth in the Delaware Basin served by Oncor's existing Wink – Culberson 138 kV Line and the Yucca Drive – Culberson 138 kV Line, referred to as The Culberson Loop. Since the RPG approval of the Oncor/AEP Far West Texas Project in May 2017, Oncor has continued to receive numerous new load additions from HV customers, many of which have requested in-service for their facilities beginning in the year 2018. As a result, Oncor recently submitted the Far West Texas DRD Project submittal, in which confirmed load service requests had reached 790 MW by 2022.

The immediate urgency for the Far West DRD Project is driven by needs to address operational and reliability issues before the new 345 kV lines can be built. Further long-term improvements for the region are still needed as the net load in The Culberson Loop continues to grow beyond the current capacity. Both during and after Oncor completed its Far West Texas DRD Project studies, Oncor has continued to see new contracted loads that will increase the total peak load served in The Culberson Loop to 1013 MW.

Table 1 below shows the confirmed load requests and the total projected non-coincident summer peak loads for The Culberson Loop. The values shown under Confirmed Load Requests includes only confirmed additions through the ERCOT 2017 Annual Load Data Request (ALDR) process and high voltage (HV) customers with contractually signed obligations. This data alone, however, provides an incomplete picture of the future load in this area because it fails to consider future load growth beyond what is contractually committed at the moment of study. In addition to new customers that have signed agreements, there are a number of new load additions in discussion that could potentially add approximately 300 MW of load to The Culberson loop beyond the load totals described above. The Total Projected Load Additions shown in Table 1 include pending additions that are in the study and contractual discussion stages between Oncor and customers, and have a probable likelihood of bringing the total load served in the loop to 1339 MW by 2023.

	Confirmed Load Requests					
	2017	**2018**	**2019**	**2020**	**2021**	**2022**
Total (MW)	**300.6**	**580.2**	**775.4**	**893.0**	**964.4**	**1013.1**
	Total Projected Load Additions					
Total (MW)	**300.6**	**670.3**	**983.8**	**1163.4**	**1292.0**	**1339.8**

Table 1- Total Projected Load (MW) Served from The Culberson Loop

Table 2 below shows a timeline of how the total Oncor load forecast for The Culberson Loop has changed over the last few years. The Total Load Forecast column shows what the total confirmed load projection was at the particular time shown in the Forecast Date column. The Timing Description column shows what RPG project was in progress at that same particular time.

Forecast Date	Total Load Forecast	Timing Description
02/2013	148 MW	Permian – Culberson Submittal
02/2016	252 MW	Riverton – Sand Lake Submittal
04/2016	425 MW	Far West TX Project Submittal
05/2017	596 MW	Far West TX Project Approval
10/2017	790 MW	Far West DRD Project Submittal
01/2018	1013 MW	Far West TX Project 2 Submittal
01/2018	1339 MW (w/load under discussion but unsigned)	Far West TX Project 2 Submittal

Table 2- Projected Load (MW) Served from The Culberson Loop Timeline

This table illustrates the rapid new load requests this area of the ERCOT system has received in a relatively short time frame and the need for system planning in this area to extend beyond contractually committed loads. The speed of growth at which many of these customers are coming online makes it difficult to construct and operate facilities to adequately serve the load in a timely fashion, makes accurately studying this area of the ERCOT system difficult, and results in plans that are potentially insufficient shortly after they are created. Restricting planning to the contractually committed load forecast for projects in this area provides no margin of error for this rapid growth.

For example when Oncor submitted the original Far West Texas Project to RPG in 2016, the forecast at that time for 2021 was 425 MW. Today Oncor forecasts that its 2018 peak load for this area will be 580 MW. Another good example of this dramatically increasing load growth is the load additions that occurred during the course of Oncor's preparation of the DRD project submittal. During Oncor's studies, the ultimate totals for The Culberson Loop increased from 790 MW to 1013 MW in the span of a few months. In addition, the total load forecast for The Culberson Loop already exceeds ERCOT's expected load serving capability for the approved Far West Texas Project (717 MW), well before CCN applications can even be filed with the Public Utility Commission for the new 345 kV lines.

Based on this recent history, it is reasonable to expect that the total net load may increase throughout the RPG review process and will be higher upon completion of ERCOT's independent review. Planning beyond the signed contractual numbers is paramount for this area of the ERCOT grid which is seeing rapidly increasing load growth. As a result, Oncor recommends planning studies be performed beyond the contracted total load of 1013 MW and to the potential load of 1339 MW.

Base Case Analysis

In the original Far West Texas Project April 2016 submittal, Oncor identified numerous contingencies that resulted in unacceptable voltage conditions. Studies showed that in 2021, multiple P6 and P7 branch outages would result in unsolved contingencies during load flow analysis. ERCOT saw similar issues and performed sensitivity studies on the area as part of the RPG review process. ERCOT's independent review determined that as load grows in the area, further improvements to the approved Far West Texas Project would be needed. Ultimately ERCOT indicated that closing the 345 kV loop between Riverton, Sandlake, and Solstice would be needed if load reached 917 MW and the addition of a dynamic reactive device (DRD) such as a Synchronous Condenser would be needed if load reached 1037 MW.

The current confirmed and future potential forecast of 1013 MW and 1339 MW exceed ERCOT's original study thresholds. Due to the near term load increases in the 2018-2020 timeframe before the Odessa EHV – Riverton 345 kV Line can be built, Oncor recommended the acceleration of the reactive compensation piece of ERCOT's original Far West Texas Project recommendations with the Far West DRD Project.

With the new updated load totals, Oncor performed studies using the ERCOT Steady State Working Group (SSWG) 2023SUM case published in October 2017 and the ERCOT Dynamics Working Group (DWG) 2023SP case published in Spring 2017 as the base cases. Table 3 below shows a summary of the adjustments that were made to the cases for simulations in the updated study.

Case Adjustment	Description
Outage of West of Pecos Solar Generation	Outage of solar generation to simulate night time conditions.
Outage of Permian Basin SES Generation	Permian Basin is normally fully dispatched in the ERCOT Regional Transmission Plan (RTP) base cases as well as the Steady State Working Group (SSWG) base cases. However in real-time

	operations, Permian Basin is not normally running and is not intended to be a 24/7 continuous operating generator. As a result, Permian Basin generation being offline is a reasonable scenario and a variation that would more closely mimic real-time operations. The results of studies in this area demonstrate worse operating conditions when the Permian Basin Plant generation is unavailable, and should be considered in analysis.
Updates for confirmed load additions (Total 1013 MW)	New HV points-of-delivery (PODs) and existing substation load updates were made per the MW values shown in Table 1 within The Culberson Loop. Load point changes can be found in the project file submissions.
Updates for potential load additions (Additional 326 MW)	New HV points-of-delivery (PODs) were added based on the expected connection locations and load projections provided by customers currently in the contractual discussion process. These customers and their data are considered private and confidential.
Addition of the Far West Texas DRD Project	Two 250 MVAR, 138 kV STATCOMs at Owl Hills Tap Sw. Sta. Please see Oncor's Far West Texas DRD RPG Submittal from December 2017 for details.

Table 3- Base Case Adjustments

Oncor studies show that even with the approved Far West Texas Project and dynamic reactive devices in place, the increased load additions will result in additional violations of the NERC standard TPL-001-04 reliability criteria. Steady state contingency analysis for the 2023 base case shows that loss of the radial Odessa EHV – Riverton 345 kV Line, a NERC category P1.2 contingency, results in multiple voltage violations along The Culberson Loop. Figure 1 below shows the voltage response of buses along The Culberson Loop when opening this line without a fault, while Figure 2 below shows the single circuit outage without a fault.

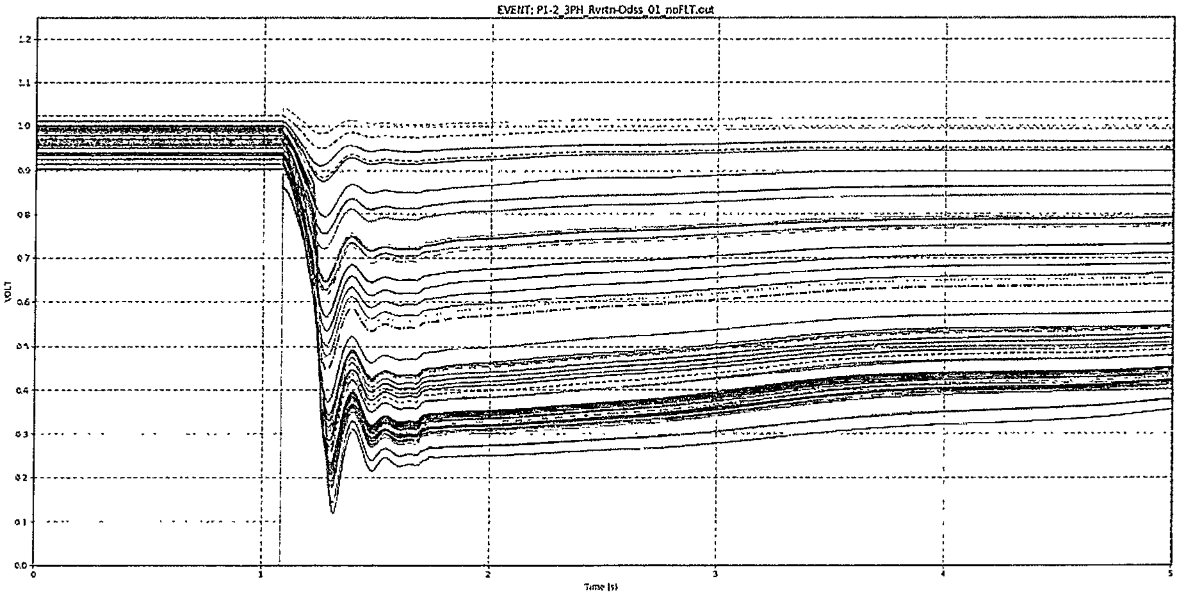


Figure 1 – Loss of Odessa EHV – Riverton 345 kV Line Voltage Response (No Fault)

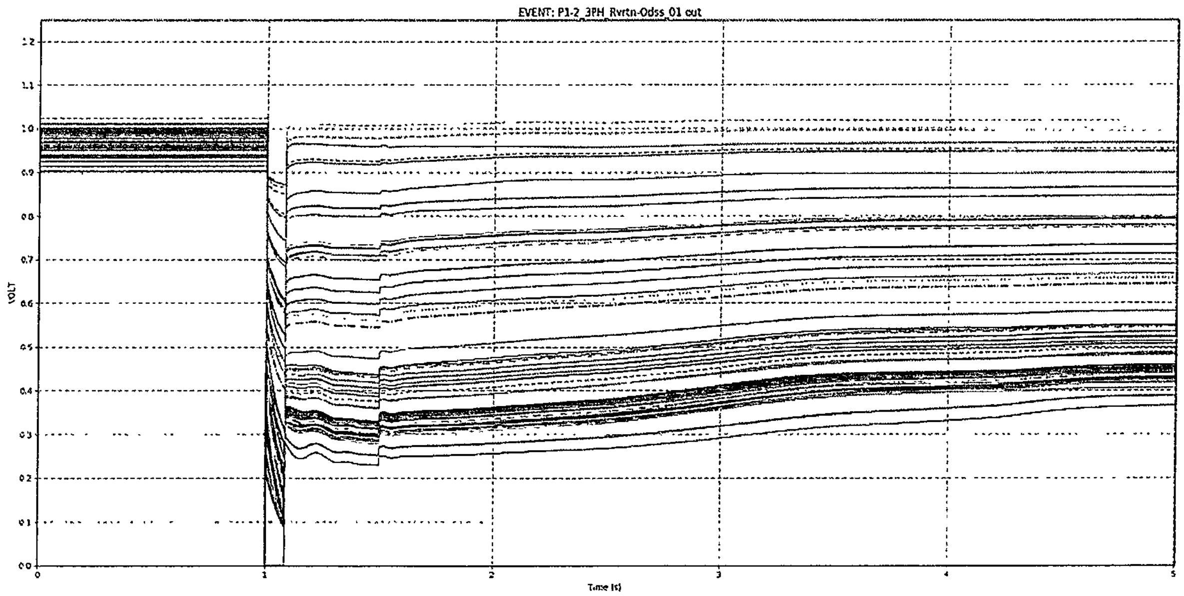


Figure 2 – Loss of Odessa EHV – Riverton 345 kV Line Voltage Response (With Fault)

The result indicates that a single-line outage of the radial 345 kV transmission line will result in a service interruption to all customers served within The Culberson Loop (1013 MWs of load in 2022). This analysis also indicates that taking a clearance on the radial 345 kV line will be problematic. As a result, there is an urgent need to close the loop and create an alternative transmission feed for the 345 kV source at Riverton when the load reaches the 1013 MW level. Creating this bi-directional feed would address these criteria violations and increase operational flexibility of the radial 345 kV line. It should be noted that this need date may be sooner, potentially as soon as 2020, based on potential load additions that are currently in contractual discussion as shown in Table 1.

Steady state contingency analysis for the 2023 base case identified additional category P1.2 and P7.1 contingencies that resulted in voltage violations under NERC Standard TPL-001-4 reliability criteria. There are six (6) different contingencies that result in the remaining line sections of The Culberson Loop to be insufficient to maintain adequate system operating conditions, resulting in an unsolved power flow. In addition, there are fifteen (15) different contingencies that result in multiple buses in The Culberson Loop being below acceptable voltage limits.

These studies show that multiple contingencies result in buses along The Culberson Loop being unable to recover to acceptable voltage levels as defined in the ERCOT Planning Guide Section 4.1.1.4. Acceptable voltage limits are defined as 0.90 per unit to 1.05 per unit in the post-contingency state following the occurrence of any operating condition in categories P1 through P7. These scenarios would ultimately result in loss of service to these customers.

Figure 3 below shows the same voltage response after loss of the Odessa EHV – Riverton 345 kV Line at the confirmed 1339 MW load level with the 345 kV loop closed. While voltage levels are able to eventually recover to acceptable levels post-contingency, there is some uncertainty as seen in the fluctuations prior to recovery. This particular simulation assumed that 10% of customer motors included voltage protection set to trip if their respective bus voltages were below 0.80 PU for 30 cycles. The abrupt vertical change in the plot at about 1.5 seconds indicates that many customer motors did trip on voltage protection during the simulation.

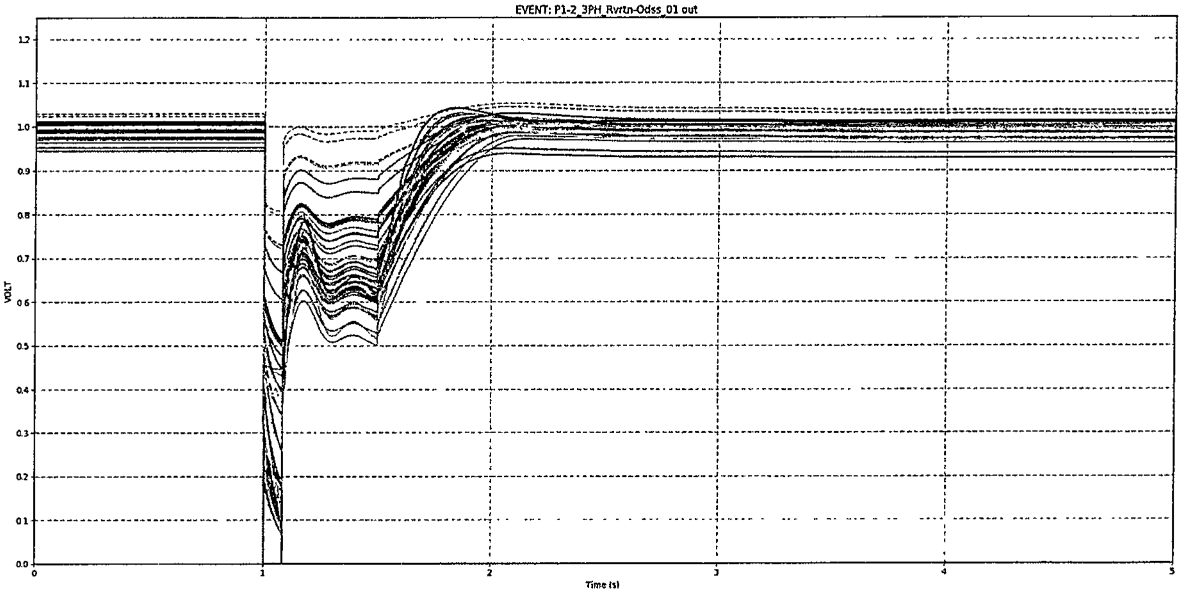


Figure 5 – Dynamic Voltage Response of The Culberson Loop for P1.2 (Odessa EHV – Riverton 345 kV Line)

Uncertainties in customer's motor behavior and protection create unknowns in the study results since estimations must be made for the dynamic load models. Majority of the loads served within The Culberson Loop are oil and gas customers who employ voltage sensitive electric equipment and motors in their operations, and have varying operational practices and philosophies on protection of their equipment. This increases the need for some margin to be provided in the proposed solution beyond the contracted load amount. Otherwise, the reliability of the transmission grid in the area could be dependent on customer owned protection and customers tripping their load. Furthermore, there is no indication that the system would support reconnection of customer load during this compromised condition.

Operational Concerns

Oncor currently has remedial operational schemes in place to mitigate post-contingency voltage violations in the area until additional facilities can be built to reliably serve the increasing load. Additional operation schemes will be needed as load within The Culberson Loop continues to grow. This may include various low voltage load shed schemes, transfer trip schemes, and load restoration procedures. In some instances, these measures will prevent the ability to reclose after a system event and prohibit eventual restoration of customers' electricity service. They may also limit operational flexibility in switching out failed equipment and restoring loads radially, putting potentially hundreds of megawatts at risk depending on the outage scenario.

As shown above in studies, taking an outage of the radial Odessa EHV – Riverton 345 kV Line may be problematic due to the reliance on the circuit for reliability of the area. This will only make an already difficult area to operate more difficult since this area of the transmission system has limited amount of transmission infrastructure. As load grows in the area, this system will become heavily reliant on the lone 345 kV source.

Table 4 shows a comparison matrix of the various stages of The Culberson Loop transmission system. Many contingencies result in significant consequential load loss. In addition, Under Voltage Load Shed (UVLS) will be required to restore the system to acceptable voltage levels. Since there are currently no mitigation alternatives to UVLS for restoring system voltage within The Culberson Loop, the out-of-service load will remain without power until the initiating problem can be corrected.

Year/Season	Load Level (MW)	Outage	NERC Category	Consequential Load Loss (MW)	Minimum UVLS (MW)	Max Load at Risk (MW)	Max Load at Risk (Percent of Total)
2018 Spring	470	Specific contingency definitions redacted for security purposes.	P7	169	65	234	50%
			P7	164			
			P7	114			
			P1	105			
2018 Fall	521		P7	190	70	260	50%
			P7	173			
			P7	120			
			P1	108			
2019 Spring	647		P7	217	75	292	45%
			P1	112			
			P1	105			
2019 Fall	655		P7	223	75	298	45%
			P7	150			
			P1	116			
			P1	107			
2022 Fall	1013		P7	441	75	516	51%
			P1	295			
			P7	152			
			P1	146			
			P7	127			
			P1	103			

Table 4 – Potential Loss of Load

As the system topology changes and more load is connected, these temporary operational measures will likely remain in place to provide margin and mitigate unresolved issues until projects are constructed. It should be noted that with the large number of new HV customers being connected to these lines over the next couple years, there will be a significant number of planned outages along The Culberson Loop, further adding to the complexity of operating the system in this area and consistently placing these lines in an N-1 state. As a result, this area of the system will present multiple operational challenges until appropriate facilities such as the Far West DRD Project and the future 345 kV infrastructure are built. While these temporary solutions are not project alternatives, they will be needed since studies show that, without these solutions in place, the system cannot maintain post-contingency system voltage in accordance with NERC TPL-001-4 requirements.

Project Description

The original Far West Texas Project RPG submittal in 2016 included a full 345 kV loop between Odessa EHV, Moss, Riverton, Sand Lake, Solstice, and Bakersfield. In addition, it included provisions for future load growth by enabling the installation of new autotransformers at stations along the proposed 345 kV transmission lines. This proposed project would complete the original proposed project by closing the 345 kV loop and installing additional autotransformers to mitigate the previously discussed violations. In addition, new 138 kV network connections are recommended to provide additional voltage support and load serving margin.

The proposed project estimated cost is $194 million and consists of the following elements:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with one circuit in place from Sand Lake Sw. Sta.to Solstice Sw. Sta. Oncor will build half the line from Sand Lake and AEP will build half the line from Solstice.
- Expand the Sand Lake Sw. Sta. to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers.
- Install the second circuit on the Riverton –Sand Lake 345 kV Line structures. Connect the new circuit from Riverton 345 kV Sw. Sta.to Sand Lake 345 kV Sw. Sta. to create the new Riverton – Sand Lake 345 kV Line.
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV Line structures (Moss – Riverton 345 kV Line)
- Construct the new Kyle Ranch Tap 138 kV Sw. Sta. in the Wink – Riverton double-circuit 138 kV Line
- Construct a new approximately 20-mile 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Substation to Riverton 138 kV Sw. Sta.
- Construct a new approximately 20-mile 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Substation to Riverton 138 kV Sw. Sta.

Second 345 kV Circuit

As shown in the studies, outage of the radial Odessa EHV – Riverton 345 kV Line will be prohibitive. As a result, addition of the 2nd circuit to the approved Odessa EHV – Riverton 345 kV Line was considered and would thus address the single circuit outage concerns. The second circuit would physically share common structures with the Odessa EHV – Riverton 345 kV Line, but would electrically be connected from the Moss 345 kV switching station. Hence the second circuit would be the new Moss – Riverton 345 kV Line, which is estimated to be 85 miles.

The addition of the second 345 kV circuit would address the P1.2 contingency concerns. The voltage response after loss of the Odessa EHV – Riverton 345 kV Line is shown below in Figure 6.

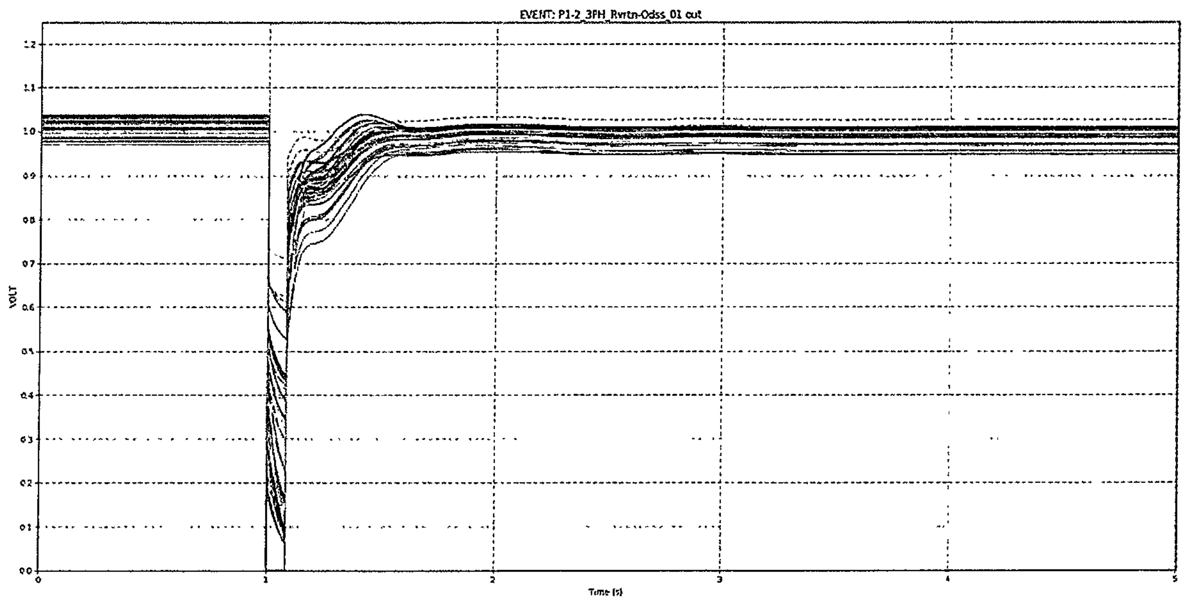


Figure 6 – Dynamic Voltage Response of The Culberson Loop for P1.2 (Odessa EHV – Riverton 345 kV Line)

Constructing the second circuit at the same time as the initial circuit would provide economic cost savings, address the P1.2 contingency, and increase operational flexibility in taking an outage on the single 345 kV circuit. In addition, it takes advantage of mobilized resources during initial construction of the Odessa EHV – Riverton 345 kV Line and avoids the need to return for construction on a newly built transmission facility. Oncor estimates the additional cost to install the second circuit during the construction of the Odessa EHV – Riverton 345 kV Line to be $32m (included in the proposed project estimate). This cost is approximately 50% less than the cost of coming back to install the second circuit at a later time due to reduced access, environmental and mobilization costs in addition to significant construction efficiencies.

New 138 kV Lines

In order to provide transmission facilities necessary to interconnect new customer loads in the area, Oncor has multiple projects to construct new 138 kV lines in the area. Example projects include the Riverton – Sand Lake 138 kV Line, Riverton – Tunstill 138 kV Line, and Orbison Tap – Balding 138 kV Line. With multiple radial taps being extended from the main lines of The Culberson Loop, there are concerns for reliability and operational flexibility, especially with the large size of these loads.

Interconnecting some of these radial lines and converting service from radial to normal looped service would not only address reliability concerns for the radially served loads, but also strengthens the transmission system by creating a more networked system to support voltage conditions and allow operationally flexibility for outages.

Oncor currently has plans to extend radials for the Owl Hills Tap – Owl Hills 138 kV Line and the Kyle Ranch Tap – Kyle Ranch 138 kV Line for new load serving substations within the Delaware Basin. These radial line extensions to serve new loads are Tier 4 Neutral projects in accordance with ERCOT Protocol

Section 3.11.4.4 (e). These new loads were included in the base case analysis with CCN filings planned by Oncor in the near future.

Ultimately, connecting these lines back to another switching station, such as Riverton, will provide such network connections and provide further paths for the future planned 345 kV injection point there.

Oncor studies showed that at the 1339 MW level, these new 138 kV connections could successfully mitigate the voltage violations mentioned previously in addition to the operational and reliability benefits described. This also provides additional transmission infrastructure in areas where little to none exists, and provides infrastructure to establish substations closer to customer's locations in the Delaware Basin.

Diagram

Figure 7 below shows the diagram of the proposed Far West Texas Project 2. The dotted lines depict the transmission line elements and the yellow depicts associated station work of the proposed Far West Texas Project 2.

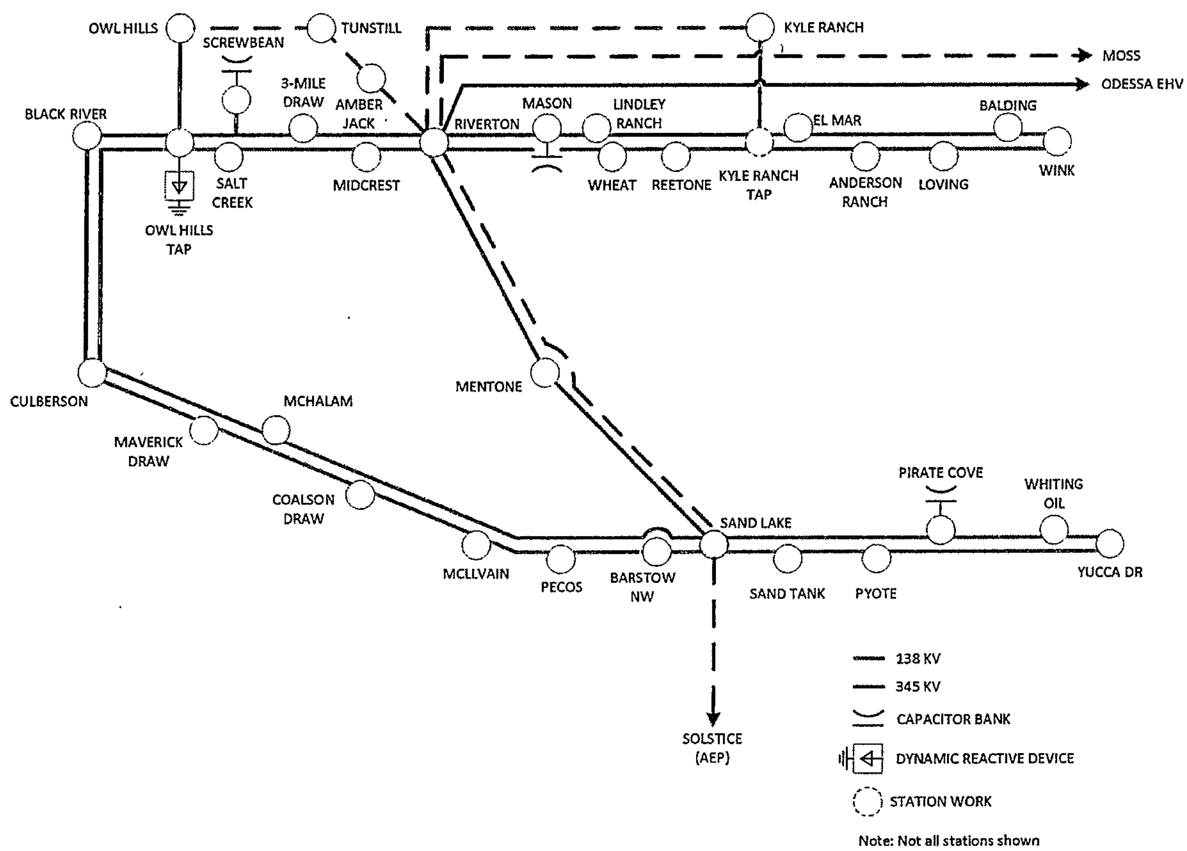


Figure 7 –Diagram

Alternatives

In ERCOT's independent review of the Far West Texas Project, ERCOT reviewed up to 40 different alternatives to the original proposed Far West Texas project. The alternatives included variations of different 138 kV and 345 kV transmission lines and reactive compensation devices.

In its evaluation of the alternatives, ERCOT identified two main options to augment the ultimately approved Far West Texas Project. Both options involved closing the 345 kV loop with added autotransformer capacity at Sand Lake Sw. Sta.

Option 1

- Addition of the 345 kV Line between Riverton – Sand Lake
- Installation of one 345/138 kV autotransformer at Sand Lake
- Construction of new 345 kV Line from Sand Lake to Solstice

Option 2

- Addition of 345 kV Line between Riverton – Sand Lake
- Installation of one 345/138 kV autotransformer at Sand Lake
- Construction of new 345 kV Line from Sand Lake to Solstice
- Installation of 200 MVAR Synchronous Condenser at Culberson

ERCOT's study for the Far West Texas Project indicated that the load serving capacity within the Culberson Loop for Option 1 would be up to 917 MW and for Option 2 up to 1037 MW. In combination with Oncor's recently submitted Far West DRD Project, Oncor's proposed solution closely mirrors ERCOT's recommended Option 2 by closing the 345 kV loop and adding dynamic reactive support.

With the current forecast (1013 MW) approaching the load serving capacity of ERCOT's Option 2 (1037 MW) and the potential 1339 MW load level imminent, additional expansion from the full build out of the Far West Texas Project is needed. As mentioned previously, the need to plan and build facilities beyond the signed contractual numbers is paramount for this area. This is especially important for future 345 kV improvements which need sufficient margin in order to ensure a robust and resilient solution for the area.

Installation of the new Far West Texas DRDs alone will not address new planning criteria violations that result from the increases in load. In addition, the DRDs alone would not close the 345 kV loop, leaving both the Odessa EHV – Riverton and the Bakersfield – Solstice 345 kV lines in radial configurations and susceptible to single outages. As mentioned previously in this report, single contingency loss of the Odessa EHV – Riverton 345 kV line, and the subsequent outage of the two Riverton 345/138 kV autotransformers results in unacceptable voltage conditions in The Culberson Loop.

Another relatively straight forward alternative to augment the existing project is to complete the full 345 kV loop between Odessa EHV – Moss – Riverton – Sand Lake – Solstice – Bakersfield as full double-circuit 345 kV lines. While this would increase operational flexibility and aid the voltage recovery post-contingency, Oncor studies show that this alone would not address individual contingency violations within the Culberson Loop at the 1339 MW level. Oncor steady-state analysis showed that there would still be multiple contingencies that would result in the remaining buses in The Culberson Loop to be below acceptable ranges.

Subsynchronous Resonance Impact

A topology screening assessment was performed to identify new potential Subsynchronous Resonance (SSR) vulnerabilities within the ERCOT system as a result of the proposed project. The assessment revealed that system changes required by the proposed project did not result in any generation resources becoming radial to series capacitors in the event of less than 14 concurrent transmission outages.

Recommendation

Oncor recommends completion of the original 2016 Far West Texas Project by closing the 345 kV loop between Riverton and Solstice and installing autotransformers at Sand Lake. Additionally, Oncor recommends that the second circuit on the Odessa EHV – Riverton 345 kV Line structures be installed at the same time, as well as the addition of two new 138 kV network connections to provide additional voltage support and load serving margin within The Culberson Loop. These projects will effectively mitigate reliability issues, provide transmission infrastructure for future loads to connect, and ensure infrastructure needs are addressed for the Delaware Basin.

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June 12, 2018

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RE: Far West Texas Dynamic Reactive Devices and Far West Texas Project 2

On June 12, 2018 the Electric Reliability Council of Texas (ERCOT) Board of Directors endorsed the following Tier 1 transmission project as needed to support the reliability of the ERCOT Regional transmission system:

Far West Texas Dynamic Reactive Devices and Far West Texas Project 2:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with two circuits in place from Sand Lake 345 kV Switch Station to Solstice 345 kV Switch Station
- Add two new 600 MVA, 345/138 kV autotransformers at Sand Lake 345 kV Switch Station
- Install a new 345 kV circuit on the planned Riverton – Sand Lake double circuit structures
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV line double circuit structures between Moss and Riverton (creating a Moss – Riverton 345 kV circuit)
- Construct a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line
- Construct a new approximately 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Substation to Riverton 138 kV Switch Station

- Construct a new approximately 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Switch Substation to Riverton 138 kV Switch Station
- Install the second 345 kV circuit on the planned Solstice Switch Station – Bakersfield Switch Station double circuit structures
- Install one 250 MVAR STATCOM at Horseshoe Springs 138 kV Switch Station
- Install one 250 MVAR STATCOM at Quarry Field 138 kV Switch Station
- Install 150 MVAR static capacitors at Horseshoe Springs 138 kV Switch Station
- Install 150 MVAR static capacitors at Quarry Field 138 kV Switch Station

Further, the Board of Directors designated the Riverton – Sand Lake 345 kV line, the Sand Lake – Solstice 345 kV line, and the Bakersfield – Solstice 345 kV line critical to the reliability of the ERCOT System. Additional details on this project are included in the Attachment A to this letter.

This project was supported throughout the ERCOT planning process, which included participation of all market segments through the ERCOT RPG. ERCOT's recommendation to the Board was reviewed by the ERCOT Regional Planning Group and the ERCOT Technical Advisory Committee (TAC). ERCOT staff looks forward to the successful completion of the work and is ready to assist you with any planning and operations related activities.

Should you have any questions please contact me at any time.

Sincerely,

D. W. Rickerson
Vice President, Grid Planning and Operations
Electric Reliability Council of Texas

cc:
Shawnee Claiborn-Pinto, PUCT
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Attachment A

ERCOT Independent Review of Oncor Far West Texas Project 2 and Dynamic Reactive Devices

Version 1.0

Document Revisions

Date	Version	Description	Author(s)
05/21/2018	1.0	Final Report	Xiaoyu Wang, Ying Li, Priya Ramasubbu
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1. Executive Summary

In June 2017, the ERCOT Board of Directors endorsed the Far West Texas Project (FWTP), a Tier 1 transmission project to address the transmission needs both in the Culberson Loop area and the Barilla Junction area that could reliably serve the Culberson Loop load up to 717 MW. Since the approval of the FWTP project in 2017, Oncor has confirmed that the Culberson Loop has contractually-confirmed load levels that surpass ERCOT's indicated 717 MW limit for the approved Far West Texas Project. Therefore, the endorsed FWTP project was assumed to be in-service in 2020 for the purpose of this study.

In December, 2017, Oncor submitted the Far West Texas Dynamic Reactive Devices (DRD) Project to the Regional Planning Group (RPG) to meet the summer 2019 Culberson Loop load need. The proposed DRD project was estimated to cost $86 million and was classified as Tier 1 project. At the time the DRD project was proposed, the Culberson Loop was projected to have 650 MW by 2019 and 790 MW by 2022 with the inclusion of the existing and confirmed load requests in the area.

In February, 2018, Oncor submitted the Far West Texas Project 2 (FWTP2) to address reliability requirements and ensure the transmission system in the area is able to meet the projected contractually-confirmed load level in the Culberson Loop. The proposed FWTP2 project was estimated to cost $194 million and was classified as a Tier 1 project. At the time the FWTP2 project was proposed, the Culberson Loop was projected to have 775 MW by 2019 and 1013 MW by 2022 with the inclusion of the existing and confirmed load requests in the area.

As of April, 2018, Oncor has confirmed that the Culberson Loop now has contractually-confirmed load levels of 880 MW for 2019 and 1013 MW for 2022. Oncor has also indicated that additional, known potential (not yet contractually-confirmed) load increases in the Culberson Loop may push the total to 1339 MW.

Based on the DRD and FWTP2 proposals, ERCOT completed the combined independent review for both projects together to determine the system needs for both near-term and long-term in a cost effective manner while providing flexibility to meet potential load growth in this region.

Based on the forecasted loads and scenarios analyzed, ERCOT determined that there is a reliability need to improve the transmission system in Far West Texas. After consideration of several project alternatives, ERCOT concluded that the upgrades identified in Option 3 meet the reliability criteria in the most cost effective manner while providing flexibility to accommodate near-term and future load growth in the area of study. Option 3 is estimated to cost $327.5 million and is described as follows:

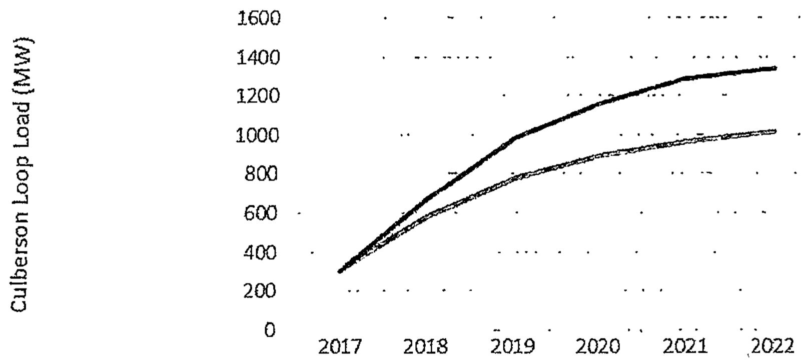
- Construct a new approximately 40-mile 345 kV line on double-circuit structures with two circuits in place from Sand Lake Switch Station to Solstice Switch Station
- Add two new 600 MVA, 345/138 kV autotransformers at Sand Lake 345 kV Switch Station
- Install a new 345 kV circuit on the planned Riverton – Sand Lake double circuit structures
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV line double circuit structures between Moss and Riverton (creating a Moss – Riverton 345 kV circuit)
- Construct a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line

- Construct a new approximately 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Switch Station to Riverton 138 kV Switch Station
- Construct a new approximately 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Switch Station to Riverton 138 kV Switch Station
- Install the second 345 kV circuit on the planned Solstice Switch Station – Bakersfield Switch Station double circuit structures
- Install one 250 MVAR STATCOM at Horseshoe Springs 138 kV Switch Station
- Install one 250 MVAR STATCOM at Quarry Field 138 kV Switch Station
- Install 150 MVAR static capacitors at Horseshoe Springs 138 kV Switch Station.
- Install 150 MVAR static capacitors at Quarry Field 138 kV Switch Station

Reactive support components, including the STATCOMs and capacitors, should be implemented by 2019 if feasible to accommodate the projected 880 MW Culberson Loop demand. Remedial operational schemes may be required in the Culberson Loop area to mitigate post-contingency voltage violations in the near-term until all of the recommended transmission upgrades can be put in-service to meet the Culberson Loop area load growth.

2. Introduction

Over the past several years the Far West Texas Weather Zone has experienced high load growth. Between 2010 and 2016 the average annual growth rate was roughly 8%. This strong growth rate was primarily driven by increases in oil and natural gas related demand. Figure 2.1 shows the total projected load (MW) served from the Culberson Loop as indicated in the Oncor's Far West Texas Project 2 (FWTP2) RPG proposal.



	2017	2018	2019	2020	2021	2022
Confirmed Load Request	300.6	580.2	775.4	893	964.4	1013.1
Total Projected Load Additions	300.6	670.3	983.8	1163.4	1292	1339.8

Year

Figure 2.1: Total Projected Load (MW) in the Culberson Loop

Load growth along the Culberson Loop has led to several transmission improvements in the area, including the Far West Texas Project (FWTP) which was endorsed by the ERCOT Board of Directors in June, 2017. The FWTP is expected to be implemented by 2020 and will be able to serve up to 717 MW of Culberson Loop load. Significant new load requests to connect to the Culberson Loop have been observed since the approval of FWTP in 2017 due to growth in the oil and gas activity. As of April, 2018, the Permian Basin oil and natural gas rig count addition by county, as shown in Figure 2.2, has increased by 28% compared to April, 2017. Also, more than 70% of newly added rigs since April, 2017 are located in the counties served by the Culberson Loop transmission system (Culberson, Reeves, Ward, Crane, Loving, and Winkler Counties).

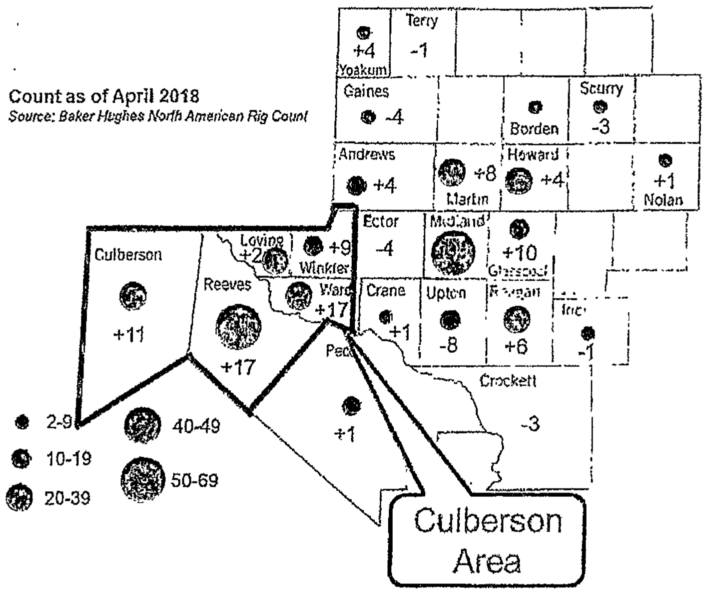


Figure 2.2 Permian Basin Oil and Natural Gas Rig Count Addition since April, 2017

In December, 2017, Oncor submitted to RPG the Far West Texas Dynamic Reactive Devices (DRD) Project, designed to meet the expected summer 2019 Culberson Loop load. The proposed DRD project was estimated to cost $86 million and was classified as a Tier 1 project. At the time of the DRD project RPG submittal, the Culberson Loop load, with the inclusion of all contractually confirmed load, was projected to be 650 MW by 2019 and 790 MW by 2022. The major components of DRD project proposal were:

- Construct a new Horseshoe Springs 138 kV Switch Station in the Riverton – Culberson 138 kV Double-circuit line
- Install two 250 MVAR, 138 kV Static Synchronous Compensators (STATCOMs) at Horseshoe Spring 138 kV Switch Station

In February, 2018, Oncor submitted the Far West Texas Project 2 (FWTP2) to address reliability requirements and ensure the transmission system in the area is able to meet the projected load. The proposed FWTP2 project was estimated to cost $194 million and was classified as a Tier 1 project. At the time the FWTP2 project was proposed, the Culberson Loop area load, again based on contractually confirmed load requests, was projected to serve 775 MW by 2019 and 1013 MW by 2022. Figure 2.3 shows the proposed FWTP2. The major components of the FWTP2 project proposal include:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with one circuit in place from Sand Lake 345 kV Switch Station to Solstice 345 kV Switch Station
- Add two new 600 MVA, 345/138 kV autotransformers at Sand Lake 345 kV Switch Station
- Install a new 345 kV circuit on the planned Riverton – Sand Lake double circuit structures
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV line double circuit structures between Moss and Riverton (creating a Moss – Riverton 345 kV circuit)

- Construct a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line
- Construct a new approximately 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Substation to Riverton 138 kV Switch Station
- Construct a new approximately 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Switch Station to Riverton 138 kV Switch Station

As of April, 2018, Oncor has updated the contractually confirmed Culberson area load to be 880 MW by summer 2019 and 1013 MW by 2022. Additional load requests could potentially push the load to more than 1300 MW in the Culberson Loop.

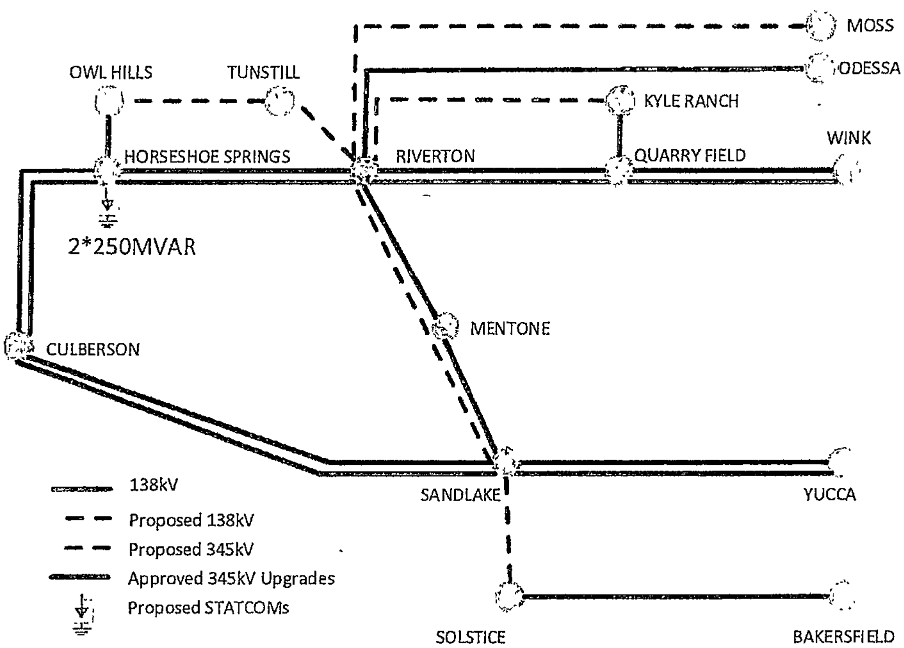


Figure 2.3: Proposed Far West Texas Project 2

Based on both the DRD and the FWTP2 proposals, ERCOT completed this independent review to determine the system needs in the Culberson Loop area and to address those needs in a cost-effective manner while providing the flexibility to meet near-term and potential long-term load growth in this area.

3. Study Assumption and Methodology

ERCOT performed studies under various system conditions to evaluate the system need and identify a cost-effective solution to meet those needs in the area. The assumptions and criteria used for this review are described in this section.

3.1. Study Assumption

The primary focus of this review is the Wink – Culberson – Yucca Drive loop transmission system, referred to as the "Culberson Loop." Figure 3.1 shows the system map of the study area.

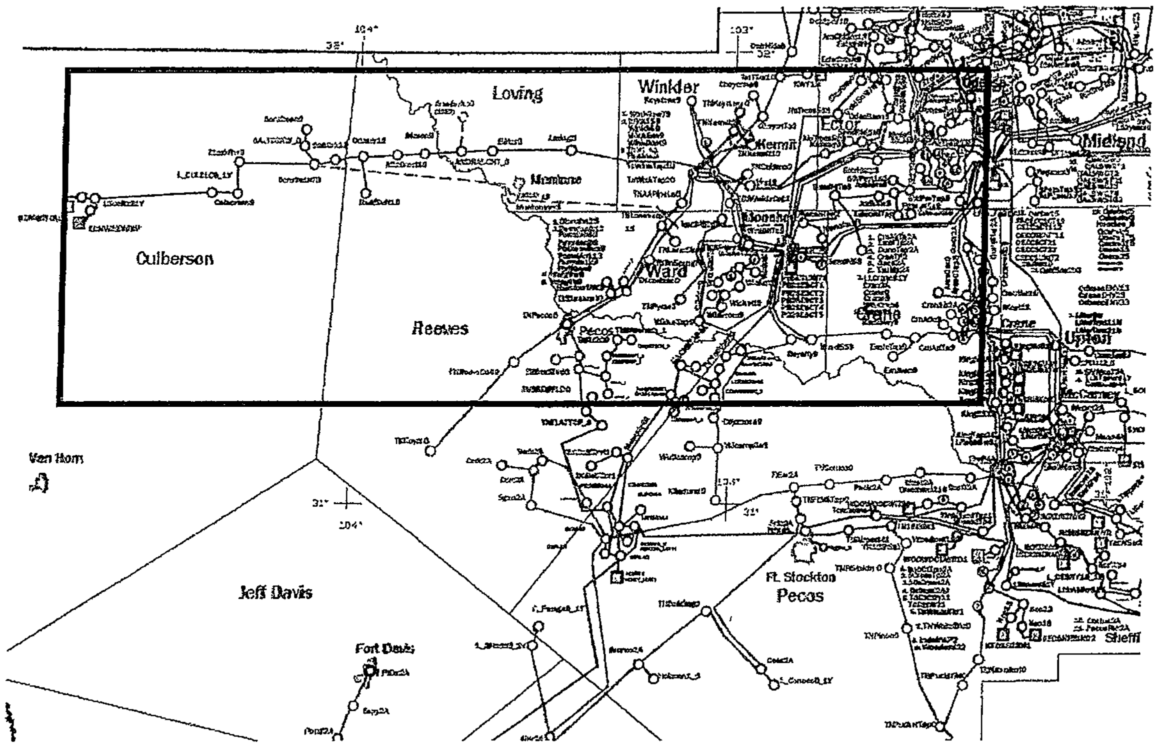


Figure 3.1: Transmission System Map of Study Area

Reliability Cases

The following starting cases were used in the study:

- The 2020 West/Far West (WFW) summer peak case from the 2017 RTP reliability case
- The 2020 Dynamics Working Group summer peak flat start case

Transmission Topology

The starting case was modified based on input from Oncor to include topological changes, switched shunt additions and load additions in the study area for both near-term 2019 summer peak and 2022 summer peak conditions.

Study Case Loads and Potential Loads

Oncor provided data regarding increased load projections in the Culberson Loop area. The most recent Oncor submittal data included 880 MW for 2019 summer peak and 1030 MW for 2022 summer peak in the Culberson Loop area. Oncor met with ERCOT and shared information on the signed customer agreements which confirmed these proposed load additions.

Sensitivity cases were also created to reflect higher potential load projections from Oncor. These cases contained additional customer load requests that did not yet have firm commitment at the time of this independent review. To reflect this "Potential" load growth, the load was increased by 334 MW in the Culberson Loop for 2022 summer peak. The total load in the Potential Load Case was approximately 1347 MW in the Culberson Loop for the Potential Load sensitivity.

Generation

Planned generators in the Far West and West Weather Zones that met Planning Guide Section 6.9 conditions for inclusion in the base cases (according to the 2016 October Generation Interconnection Status report), which were not included in the RTP cases, were added. The added generators are listed in Table 3.1.

Table 3.1 Added Generators That Met Planning Guide Section 6.9 Conditions (2018 April GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
14INR0044	West of Pecos Solar	100	Solar	Reeves	Far West

Key assumptions applied in this study include the following:

- Wind generation in West and Far West weather zones were set to have a maximum dispatch capability of 2.6% of their rated capacity. This assumption was in accordance with the 2016 Regional Transmission Plan Study Scope and Process document[1].
- Solar generation was set at 70% of their rated capacity in accordance with the 2016 Regional Transmission Plan Study Scope and Process document.
- Considering the oil and gas industry load characteristics (flat load), the most stressed system condition is during the night when solar generation is not available. To study this condition, no solar generation was dispatched in the study base conditions.

Capital Cost Estimates

Capital cost estimates for transmission facilities were provided by Oncor, AEPSC and LCRA TSC. These costs were provided for individual transmission facilities and ERCOT used those values to calculate total project costs for various project options.

3.2. Criteria for Violations

The following criteria were used to identify planning criteria violations.

All 100 kV and above busses, transmission lines, and transformers in the study region were monitored (excluding generator step-up transformers).

- Thermal criteria violations
    - Rate A for Normal Conditions

[1] http://www.ercot.com/content/wcm/key_documents_lists/77730/2016_RTP_Scope_Process_v1.3_clean.pdf

  - Rate B for Emergency Conditions
- Voltage violation criteria
  - 0.95 < V pu < 1.05 Normal
  - 0.90 < V pu < 1.05 Emergency
  - Post Contingency voltage deviations
    - 8% on non-radial load buses
- Dynamic Stability Analysis
  - NERC TPL-001-4 and ERCOT Planning Guide Section 4

3.3. Study Tools

ERCOT utilized the following software tools for the independent review of the Far West Texas Project:

- PSS/e version 33 was used to perform the dynamic stability analysis and in the initial steady-state case creation to incorporate the TSP idvs files
- PowerWorld Simulator version 20 for SCOPF and steady state contingency analysis
- VSAT *version 17 was used for voltage stability analysis*
- UPLAN version 10.2.0.19928

4. Project Need

The need for a transmission improvement project was evaluated for the Study Case. Table 4.1 summarized the steady state voltage stability (Power-Voltage) assessment results for the 2019 summer peak. The results showed pre-contingency voltage stability issues with no transmission upgrades. Even with the addition of the ERCOT Board of Directors approved Far West Texas Project (FWTP), as shown in Table 4.1 Scenario 2, the results indicated both voltage violations and voltage collapse under certain contingencies for the projected Culberson Loop 2019 summer peak load. The project need analysis results are consistent with the finding of the 2017 FWTP ERCOT independent review that identified the need for additional upgrades (beyond the FWTP project endorsed in June 2017) to serve loads greater that 717 MW in the Culberson Loop.

Table 4.1 Steady State Voltage Stability Assessment for the Base Case Condition

Scenario	Load (MW)	Transmission Upgrades	Culberson Load Serving Capability	
			NERC P1, P7	NERC P6
1.	880 (2019 Summer Peak)	None	Pre-contingency Voltage Collapse	
2.	880 (2019 Summer Peak)	FWTP(1)	Voltage Violation Voltage Collapse	Voltage Violation Voltage Collapse

(1). The Far West Texas Project (FWTP) endorsed by ERCOT Board of Directors in June, 2017.

5. Project Options

5.1. Options Considerations

The FWTP, which was endorsed by the ERCOT Board of Directors in June 2017, was designed to allow for a number of different expansion options that could accommodate additional load growth. All project alternatives considered in this study align with the expansion options evaluated as part of the ERCOT FWTP independent review.

In addition, project options considered in this study were limited to alternatives that included adding a second 345 kV circuit to the Odessa EHV – Riverton (between Moss and Riverton) and Solstice – Bakersfield 345 kV lines. This limitation was result of the following considerations:

- The Culberson Loop area has experienced a significant rate of load growth. This evaluation focused on contractually committed load with a sensitivity evaluation which includes new customers that have contacted the TSPs with load requests but have not yet finalized a contract to construct. However, it is possible that more, presently unknown, load requests will materialize before the facilities recommended in this evaluation are in service.
- The Odessa EHV – Riverton and Solstice – Bakersfield 345 kV lines have yet to be constructed. If they were constructed with one circuit in place and a second 345 kV circuit was later deemed necessary, the construction outage to add the second circuit would greatly reduce the load serving capability to the Culberson Loop and reduce the operational flexibility during what would likely be a long duration outage.
- It is approximately 50% less expensive to construct the two circuits in place at the initial build than the cost of coming back to install the second circuit at a later time due to reduced access, environmental and mobilization costs, and construction efficiencies.

In addition, the new 138 kV lines proposed in the FWTP2 project are necessary to strengthen the Culberson Loop and provide operational flexibility under normal and outage conditions.

5.2. Short-Listed Options

Based on the considerations listed above and the results of preliminary analysis, the following "universal" transmission upgrades were included in all of the short-listed options:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with two circuits in place from Sand Lake 345 kV Switch Station to Solstice 345 kV Switch Station
- Add two new 600 MVA, 345/138 kV autotransformers at Sand Lake 345 kV Switch Station
- Install a new 345 kV circuit on the planned Riverton – Sand Lake double circuit structures
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV line double circuit structures between Moss and Riverton (creating a Moss – Riverton 345 kV circuit)
- Construct a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line
- Construct a new approximately 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Substation to Riverton 138 kV Switch Station

- Construct a new approximately 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Switch Substation to Riverton 138 kV Switch Station
- Install the second 345 kV circuit on the planned Solstice Switch Station – Bakersfield Switch Station double circuit structures

The following three options were studied further for the reactive support in the Culberson Loop. The detailed description of the three short-listed options are provided below and diagrams for these are included in the Appendix.

Option **1**

- Universal transmission upgrades
- Install two 250 MVAR Static Synchronous Compensators (STATCOMs) at Horseshoe Springs 138 kV Switch Station

The total cost estimate for Option 1 is approximately $300.0 Million.

Option **2**

- Universal transmission upgrades
- Install one 250 MVAR Static Synchronous Compensators (STATCOMs) at Horseshoe Springs 138 kV Switch Station
- Install capacitor banks with a total capacity of 150 MVAR at Horseshoe Springs 138 kV Switch Station.
- Install capacitor banks with a total capacity of 150 MVAR at Quarry Field 138 kV Switch Station

The total cost estimate for Option 2 is approximately $292.5 Million.

Option **3**

- Universal transmission upgrades
- Install one 250 MVAR Static Synchronous Compensators (STATCOMs) at Horseshoe Springs 138 kV Switch Station
- Install one 250 MVAR Static Synchronous Compensators (STATCOMs) at Quarry Field 138 kV Switch Station
- Install capacitor banks with a total capacity of 150 MVAR at Horseshoe Springs 138 kV Switch Station
- Install capacitor banks with a total capacity of 150 MVAR at Quarry Field 138 kV Switch Station

The total cost estimate for Option 3 is approximately $327.5 Million.

6. Voltage Stability and Dynamic Stability Analysis

A Power-Voltage (PV) analysis was used in the steady state voltage stability assessment for the Culberson Loop area for all short-listed options for the studied scenarios. A Power-Voltage (PV) analysis was used to proportionally increase the load in the Culberson Loop until a voltage collapse identified the maximum load serving capability for the options. Table 7.1 shows the results of this analysis, indicating the maximum loads in the Culberson Loop area that can be reliably served by the three identified project options. A sensitivity analysis was conducted to evaluate the impact of nearby generators to the Culberson Loop load serving capability. All five generators at the Permian Basin (PBSES) generation station were off-line in the study case. The PV results are in listed in Table 7.1.

Table 7.1 Voltage and Dynamic Stability Assessment of All Options for Culberson Loop Load Serving Capability

	Culberson Loop Load Served (MW)		
Description	Option 1	Option 2	Option 3
PV Voltage Collapse Results (NERC P1, P6, P7, ERCOT Events)	1608	1568	1688
PV Voltage Collapse Results (without PBSES Units) (NERC P1, P6, P7, ERCOT Events)	1508	1468	1648
Dynamic Stability Result (without PBSES Units) (NERC P1, P6, P7, ERCOT Events)(1)	Acceptable	Acceptable	Acceptable
Estimated Capital Cost ($M)	300	292.5	327.5

(1). Dynamic stability was conducted at the Culberson Loop load level identified in the PV voltage collapse results.

The majority of the loads in the study area were assumed to be oil and gas customers who employ voltage-sensitive electric equipment in their operations. As specified by Oncor, heavy motor load was assumed to represent the load characteristic in the study area. All three options were tested using time domain dynamic stability simulations including a dynamic load model provided by Oncor to evaluate system stability.

It was assumed that if simulations indicated an acceptable (stable) system response following severe events and/or three-phase faults, the stability response would also be acceptable for the same events with a single-line-to-ground (SLG) fault. If a potential stability issue was observed, the simulation was rerun with SLG faults to ensure a stable system response following a NERC planning event. In this way the analysis demonstrated compliance with NERC planning standards and ERCOT reliability criteria. In these simulations, selected ERCOT transmission buses were monitored for angle and voltage responses.

The dynamic event definitions included the removal of all elements that the protection system and other automatic controls are expected to disconnect for each event. The dynamic simulation results are also listed in Table 7.1.

None of the three options will be fully in-service prior to summer 2019, when the load is projected to reach 880 MW, since the new transmission lines will not be constructed. As a result, a PV analysis was conducted for the 2019 summer condition assuming only the reactive devices in all three options can be implemented to support the Culberson Loop in 2019. The PV analysis results are listed in Table 7.2. The results indicate that for Options 1 and 2 additional operational mitigation measures will be needed to maintain reliability prior to the new transmission lines being put in place. These operational mitigation measures may include (but are not limited to) undervoltage load shed.

Table 7.2 Steady State Voltage Stability Assessment of All Options for Culberson Loop Load Serving Capability with Reactive Devices Only

	Culberson Loop Load Served (MW)		
Description	Option 1	Option 2	Option 3
PV Voltage Collapse Results (reactive devices only[1] (NERC P1, P6, P7, ERCOT Events)	801	821	1001
PV Voltage Collapse Results (without PBSES units) (reactive devices only[1] (NERC P1, P6, P7, ERCOT Events)	721	741	880[2]

(1). Assuming reactive devices will be in service before new transmission lines.

(2). Oncor indicated that the reactive devices identified to be located at Quarry Field 138 kV Switch Station may not be in service by summer 2019. ERCOT performed a PV analysis considering only the reactive devices located at Horseshoe Springs from Option 3. The results showed that without the Quarry Field reactive devices in service, Option 3 would have a load serving capability of 721 MW.

7. Economic Analysis

Although this RPG project is driven by reliability needs, ERCOT also conducted an economic analysis to identify any potential impact on system congestion related to the addition of the transmission upgrades.

The base case for this economic analysis used the 2023 economic case built for the 2017 RTP as the starting case. The topology changes and generation additions were similar to the steady state base case built. ERCOT modeled each of the three short-listed options and performed production cost simulations for the year 2023. The annual production analysis showed no measurable congestion impact on the ERCOT System with the addition of the transmission upgrades.

8. Subsynchronous Resonance (SSR) Vulnerability Assessment

According to Protocol Section 3.22.1.3(2), ERCOT performed a SSR vulnerability assessment using topology check and the results indicated that all three short-listed options strengthen the transmission network and increase the required transmission circuit outages to have a Generation Resource become radial to series capacitors. The SSR assessment results showed no SSR vulnerability for any existing Generation Resources or Generation Resources satisfying Planning Guide Section 6.9 conditions for inclusion in the planning models at the time of this study.

9. Final Options Comparison

As shown in Table 9.1, a comparison of study results for the three options shows that Option 3, shown in Figure 9.1, met the system reliability criteria under the studied load conditions while providing better load serving capability to accommodate both the near-term and potential future load needs in the Culberson Loop area.

Table 9.1 Options Comparison

Description	Option 1	Option 2	Option 3
Capital cost ($ Million)	300.0	292.5	327.5
PV Results, Culberson Load Served	1608	1568	1688
PV Results, Culberson Load Served (with only reactive support devices recommended in the options)	801	821	1001
PV Results, Culberson Load Served (without PBSES Units)	1508	1468	1648
PV Results, Culberson Load Served (without PBSES Units) (with only reactive support devices recommended in the options)	721	741	880
Dynamic Stability Results, Culberson Load Served	Acceptable	Acceptable	Acceptable

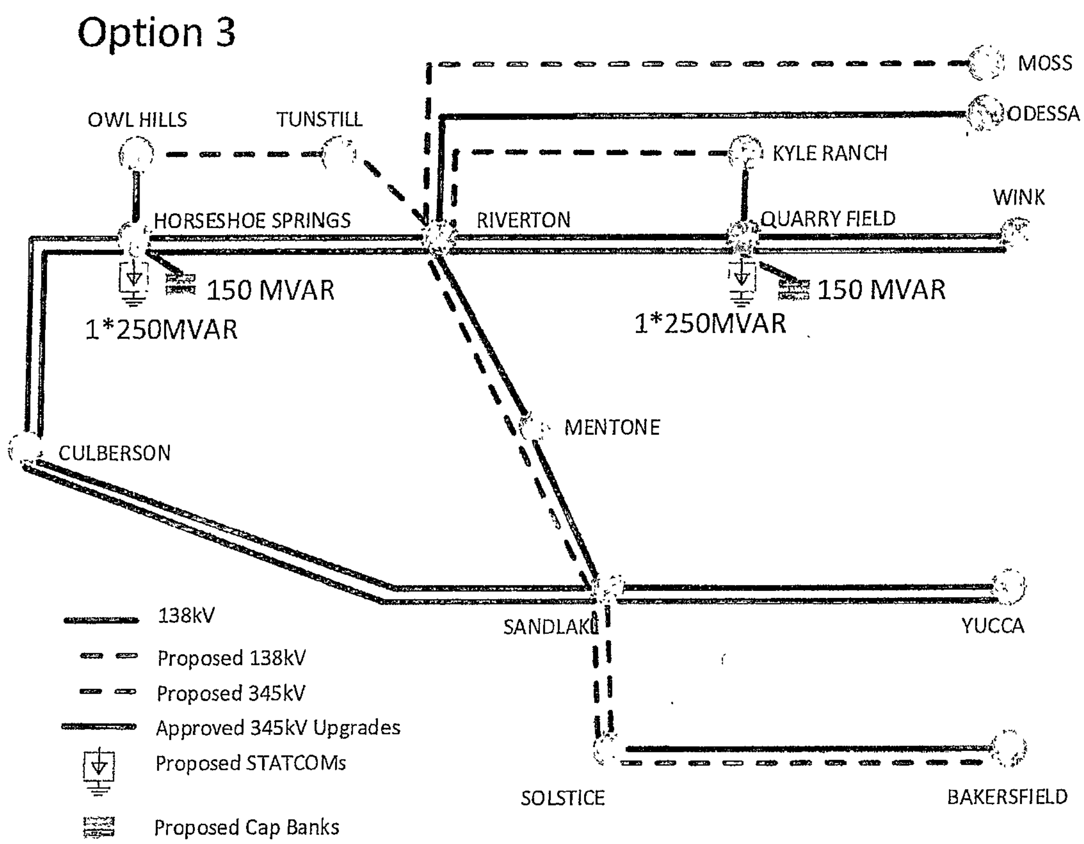


Figure 9.1: Option 3

10. Sensitivity Studies

Sensitivity studies were performed to ensure compliance with Planning Guide requirements.

10.1. Generation Sensitivity Analysis

According to Planning Guide Section 3.1.3(4)(a), the generation sensitivity analysis will evaluate the effect that proposed Generation Resources in or near the study area will have on a recommended transmission project. Based on the 2018 April Generator Interconnection Status report, Table 10.1.1 shows all the generators in the area that met Planning Guide 6.9 and Table 10.1.2 shows all the generators in the area with a signed standard generator interconnection agreement (SGIA) that did not meet Planning Guide 6.9 conditions for inclusion in the planning models. Considering the oil and gas industry load characteristics, the most stressed system condition is during the night when solar generation is not available. No solar generation in the Culberson Loop was assumed available in the study base conditions. Therefore, the proposed Generation Resources in the Culberson Loop area will have no impact on the recommended transmission project.

Table 10.1.1 Generators Met Planning Guide Section 6.9 Conditions (2017 March GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
14INR0044	West of Pecos Solar	100	Solar	Reeves	Far West

Table 10.1.2 Generators with SGIA That Did Not Meet Planning Guide Section 6.9 Conditions (2017 March GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
18INR0022	Winkler Solar	150	Solar	Winkler	Far West

10.2. Load Scaling Impact Analysis

Planning Guide Section 3.1.3(4) (b) requires evaluation of the impact of various load scaling on the criteria violations seen in the study cases.

Because the voltage violations were observed at load serving buses inside the Culberson Loop, ERCOT assumed that the load scaling in the outside weather zones did not have a material impact on the observed need.

11. Conclusion

Based on the forecasted loads and scenarios analyzed, ERCOT determined that there is a reliability need to improve the transmission system in Far West Texas. After consideration of the project alternatives, ERCOT concluded that the upgrades identified in Option 3 meet the reliability criteria in the most cost effective manner and provide needed load serving capability to the rapid oil and gas industry load growth in the Culberson Loop area. Option 3 is estimated to cost $327.5 million and is described as follows:

- Construct a new approximately 40-mile 345 kV line on double-circuit structures with two circuits in place from Sand Lake 345 kV Switch Station to Solstice 345 kV Switch Station
- Add two new 600 MVA, 345/138 kV autotransformers at Sand Lake 345 kV Switch Station
- Install a new 345 kV circuit on the planned Riverton – Sand Lake double circuit structures
- Install the second 345 kV circuit on the Odessa EHV – Riverton 345 kV line double circuit structures between Moss and Riverton (creating a Moss – Riverton 345 kV circuit)
- Construct a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line
- Construct a new approximately 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures with one circuit in place from Kyle Ranch 138 kV Substation to Riverton 138 kV Switch Station
- Construct a new approximately 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double circuit structures with one circuit in place from Owl Hills 138 kV Switch Substation to Riverton 138 kV Switch Station
- Install the second 345 kV circuit on the planned Solstice 345 kV Switch Station – Bakersfield 345 kV Switch Station double circuit structures
- Install one 250 MVAR STATCOM at Horseshoe Springs 138 kV Switch Station
- Install one 250 MVAR STATCOM at Quarry Field 138 kV Switch Station
- Install 150 MVAR static capacitors at Horseshoe Springs 138 kV Switch Station
- Install 150 MVAR static capacitors at Quarry Field 138 kV Switch Station

The reactive support components, including STATCOMs and capacitors, recommended in Option 3 should be implemented by 2019 if feasible to accommodate the projected 880 MW Culberson Loop in summer 2019. Additionally, the sizing of capacitor bank stages should take into account operational considerations. Remedial operational schemes may be required to mitigate post-contingency voltage violations in the Culberson Loop area until the recommended transmission upgrades can be built to reliably serve the increasing load.

12. Designated Provider of Transmission Facilities

In accordance with the ERCOT Nodal Protocols Section 3.11.4.8, ERCOT staff is to designate transmission providers for projects reviewed in the RPG. The default providers will be those that own the end points of the new projects. These providers can agree to provide or delegate the new facilities or inform ERCOT if they do not elect to provide them. If different providers own the two ends of the recommended projects, ERCOT will designate them as co-providers and they can decide between themselves what parts of the recommended projects they will each provide.

Oncor owns the Odessa EHV Switch Station, Moss Switch Station and is planning to construct and own the new Riverton Switching Station and therefore is the presumed owner of the Riverton Switching Station. Therefore, ERCOT designates Oncor as the designated provider for the 345 kV Odessa EHV to Riverton and Moss to Riverton transmission facilities along with the two recommended 345/138 kV autotransformers at Riverton.

LCRA TSC owns the Bakersfield Switchyard while AEPSC is constructing and planning to own the new Solstice Substation and therefore is the presumed owner of the Solstice Substation. Therefore, ERCOT designates AEPSC and LCRA TSC as the designated co-providers for the 345 kV Bakersfield to Solstice transmission facilities but AEPSC as the provider of the two recommended 345/138 kV autotransformers at Solstice.

Oncor is planning to construct and own the new Sand Lake Switching Station and therefore is the presumed owner of the Sand Lake Switching Station, while AEPSC is constructing and planning to own the new Solstice Substation and therefore is the presumed owner of the Solstice Substation. ERCOT designates Oncor and AEPSC as the designated co-providers for the 345 kV Sand Lake to Solstice transmission facilities and Oncor as the provider of the two recommended 345/138 kV autotransformers at Sand Lake Switch Station.

Oncor owns all the 138 kV Switch Stations listed in the recommended Option 3. Therefore, ERCOT designates Oncor as the designated provider for all the 138 kV transmission facilities along with the proposed STATCOMs and static capacitor banks.

The designated TSPs have requested critical designation status for the Riverton – Sand Lake 345 kV Line, the Sand Lake – Solstice 345 kV Line, and the Bakersfield – Solstice 345 kV line for multiple operational and reliability needs to address the rapid load growth in the Culberson Loop area. ERCOT designates the project critical to reliability per PUCT Substantive Rule 25.101(b)(3)(D).

13. Appendix

Options Diagrams	Options_OneLine.pptx